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ANALYSIS OF EFFECTIVENESS AND COSTS OF RETROFIT EMISSION CONTROL SYSTEMS FOR USED MOTOR VEHICLES. VOLUME IV. TEST AND ANALYTICAL PROCEDURES

Olson Laboratories, Incorporated
Anaheim, California

May 1972

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ANALYSIS OF EFFECTIVENESS AND COSTS of RETROFIT EMISSION CONTROL SYSTEMS for USED MOTOR VEHICLES

volume IV

test and analytical procedures

prepared under
EPA Contract 68-04-0038

by
Olson Laboratories, Inc.
500 East Orangethorpe Avenue
Anaheim, California 92801

In Association With Northrop Corporation

Report 71Y233
MAY 1972

for

ENVIRONMENTAL PROTECTION AGENCY
Office of Air Programs
Division of Emission Control Technology
2565 Plymouth Road
Ann Arbor, Michigan 48105

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This report was prepared for the United States Environmental Protection Agency by Olson Laboratories, Inc. pursuant to an Environmental Protection Agency contract to evaluate automotive emission control retrofit methods. The information presented in this report in no way represents any endorsement or warranty by either the contractor or the United States government of any specific device reported on; nor does it represent any conclusion about the merits of any specific device which was not evaluated. The report is based on the contractor's evaluation of laboratory data developed under the contract, retrofit developer supplied data, and government furnished data when available. The information furnished herein is believed accurate and current as of May 1972.

FOREWORD

The Environmental Protection Agency, as Administrator of the Clean Air Amendments Act of 1970, is required to assist States and air pollution control agencies in meeting national ambient air quality standards and mobile or stationary source emission standards, by issuing information on control techniques. Contract 68-04-0038 was performed with the Office of Air Programs, Division of Emission Control Technology, to determine what emission control techniques are feasible for retrofit to used cars, considering emission reduction effectiveness, costs, effect on vehicle performance, and the facilities and labor skills required for retrofit device installation and eventual maintenance and inspection. This report documents the results obtained, the pertinent data upon which the results are based, the techniques of test and analysis, and the recommendations for future programs to implement the results. The report consists of the following six volumes:

I. Program Summary: Highlights the principal program results and conclusions as to the overall feasibility of retrofit methods for vehicle emission control. Provides guidelines for the evaluation of retrofit approaches and the implementation of control programs.

II. System Descriptions: Documents the physical, functional, and performance characteristics of the candidate retrofit methods and their installation requirements and costs.

III. Performance Analysis: Documents the relative effectiveness and costs of retrofit methods, the techniques of analysis and testing, and the assumptions and rationale upon which the analysis was based.

IV. Test and Analytical Procedures: Documents the approach to the overall program objectives and the tasks and procedures implemented to meet the objectives.

V. Appendices: Documents the raw data obtained from retrofit development sources and data of overall applicability to the report.

VI. Addendum for Durability Tests: Documents the results of 25,000-mile durability tests on four representative retrofit devices.

ACKNOWLEDGMENTS

This program was conducted under the direction and with the assistance of Dr. Jose L. Bascunana, Project Officer of the Environmental Protection Agency. Emission Control Technology, Inc., provided the methodology for performance analysis under a subcontract agreement with Olson Laboratories, Inc.

The accomplishment of this program was made possible by the cooperation and assistance of the many developers and manufacturers of retrofit devices. Their contribution of coordination time, data, and retrofit device hardware is very much appreciated.

GLOSSARY

AMA	Automobile Manufacturers Association
CEI	Cost Effectiveness Index
CI	Cost Index
CID	Cubic inch displacement
CNG	Compressed natural gas
CO	Carbon monoxide
CVS	Constant volume sampling
DI	Driveability Index
EGR	Exhaust gas recirculation
EI	Emission Index
EPA	Environmental Protection Agency
gm/mi	Grams per mile
HC	Hydrocarbons
LNG	Liquefied natural gas
LPG	Liquefied petroleum gas
MMBM	Mean-miles-before-maintenance
MMBPF	Mean-miles-before-partial-failure
MMBTF	Mean-miles-before-total-failure
mph	Miles per hour
mpg	Miles per gallon
MTTM	Mean-time-to-maintain
MTTR	Mean-time-to-repair
NDIR	Nondispersive infrared
NOx	Oxides of nitrogen
OEM	Original equipment
PCV	Positive crankcase ventilation
PI	Performance Index
ppm	Parts per million
SAE	Society of Automotive Engineers
WOT	Wide open throttle

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SECTION 1
INTRODUCTION

The purpose of Volume IV is twofold: first is to document the details of the approach used to determine the effectiveness and costs of retrofit methods for used cars; and second is to provide the test and analytical tools developed through this program for use in future research and development programs in retrofit technology.

This volume describes the test and analytical tasks that were performed to meet the objectives and requirements of Contract 68-04-0038 and the procedures, methodology, and facilities that were used to implement the tasks. These tasks and their means of implementation constitute the basic Plan of Performance (Contract Article III-A) by which the effectiveness and costs of retrofit methods for used car emission control were determined. As presented herein, the tasks, procedures, and methodology constitute the final update of the Plan of Performance to incorporate revisions and refinements made in the course of performing the study.

1.1 PROGRAM OBJECTIVES

The objective of this program was to determine what methods of air-pollutant emission control can be feasibly retrofitted to light-duty used cars at this time; and to investigate their relative emission reduction effectiveness, installation and operating cost penalties or advantages, and effect on vehicle performance, including driveability, reliability, maintainability, and safety.

The main purpose was to provide, to the States and other agencies which have to establish or evaluate motor vehicle emission control programs, as much information as possible describing what methods exist, what their use would contribute to reduced emissions, and what the cost would be. The results also would be useful in defining future programs to develop the additional data needed to implement the use of retrofit methods on used cars.

1.2 PROGRAM APPROACH

The principal steps and interdependencies of the approach to accomplishing the program objectives are shown in Figure 1-1. The program was initiated by performing a thorough search for all sources of information on retrofit methods and developers. Each source was sent a letter describing the purpose of the program and requesting program participation. Each respondee expressing interest in participating and who was an actual or candidate retrofit method developer or producer was sent a request to provide data on his device. These data were used

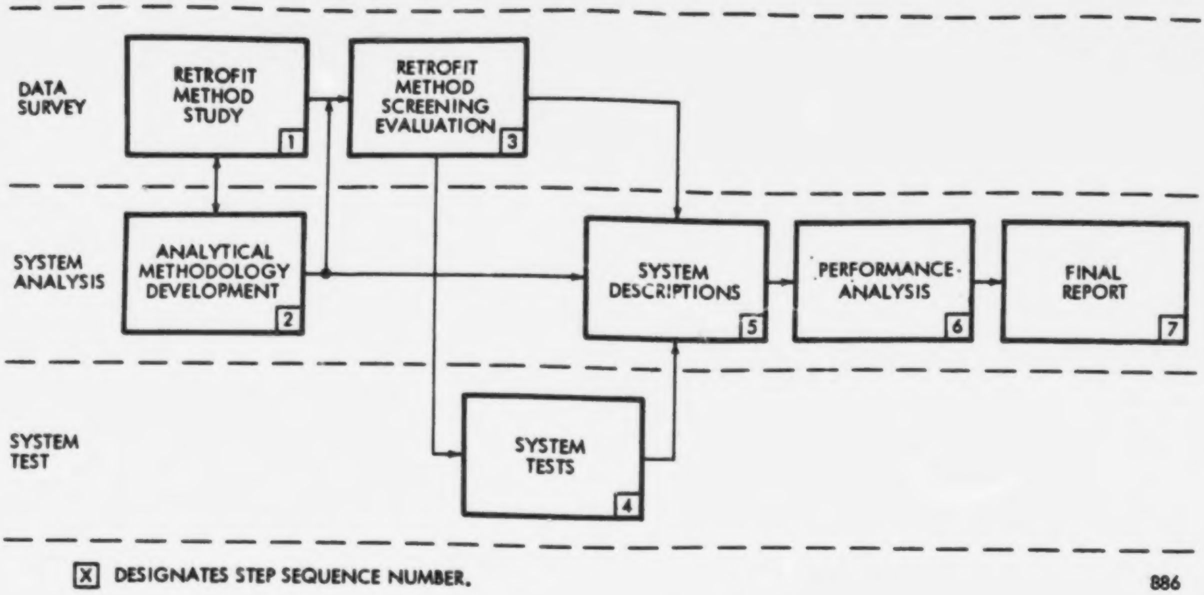
DATA SURVEY
SYSTEM ANALYSIS
SYSTEM TEST
RETROFIT METHOD STUDY 1
RETROFIT METHOD SCREENING EVALUATION 3
ANALYTICAL METHODOLOGY DEVELOPMENT 2
SYSTEM DESCRIPTIONS 5
PERFORMANCE ANALYSIS 6
FINAL REPORT 7
SYSTEM TESTS 4
X DESIGNATES STEP SEQUENCE NUMBER.
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Figure 1-1. PROGRAM APPROACH TO DETERMINING EFFECTIVENESS AND COSTS OF RETROFIT METHODS

to screen the devices by type of retrofit method and feasibility rank. The more reasonably feasible and representative devices were selected for a test program designed to provide a common baseline of performance data obtained on motor vehicles representative of that part of the used car population without emission controls.

Concurrent with the test program each device for which sufficient data were obtained was studied and analyzed to document its technical characteristics, cost, and vehicle performance impact. Data obtained both through these tests and analyses were then processed through a computer programmed mathematical model, which integrated the principal performance parameters for qualitative and quantitative analysis. This analysis included the relative effectiveness and costs of each device and group.

Based on the test and analytical results, conclusions were made as to the current state of retrofit method technology, the guidelines for applying retrofit methods to the requirements of air pollution control agencies, and the requirements for future programs.

1.3 PROGRAM SCHEDULE

The major milestones of program accomplishment are shown in Figure 1-2. Progress reports were submitted monthly. Technical review meetings were held monthly by a board composed of the key program technical management personnel identified in Figure 1-3.

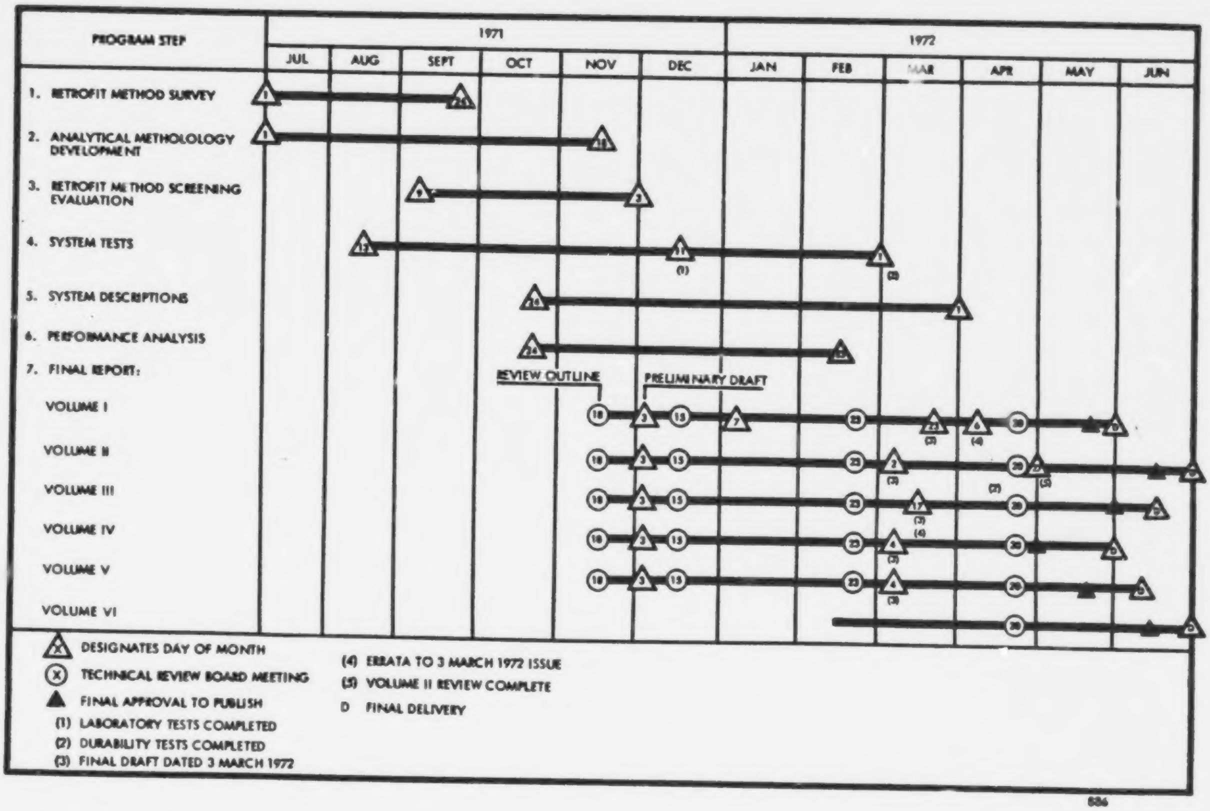
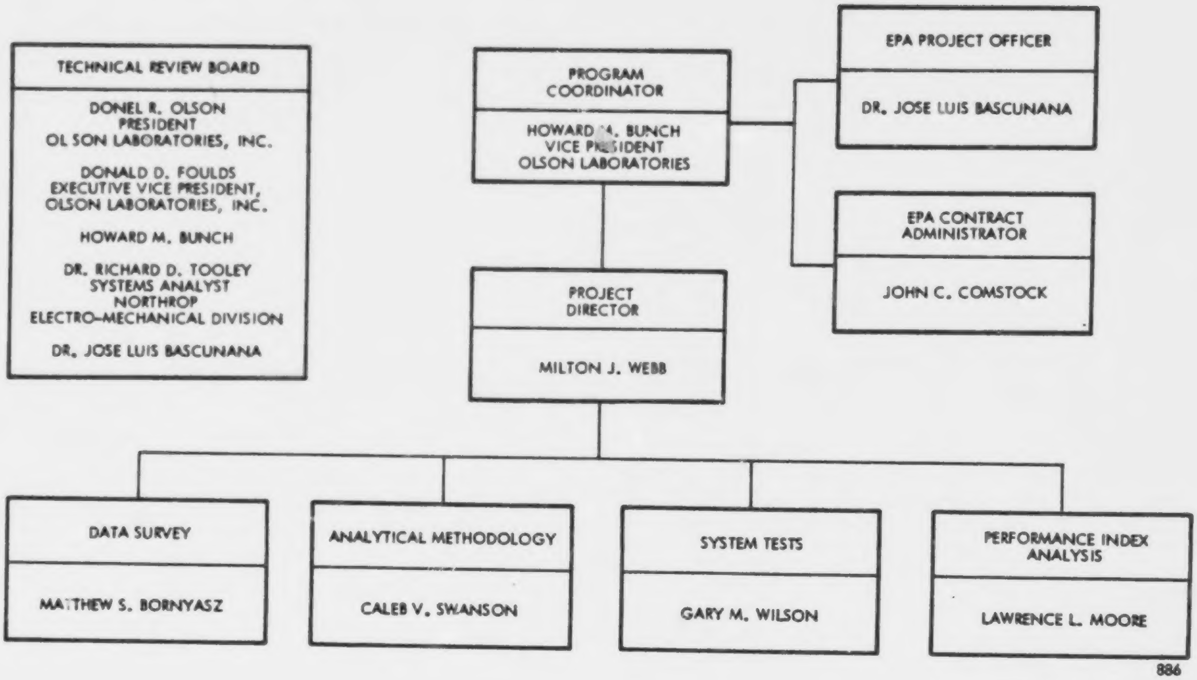


Figure 1-2. PROGRAM MASTER SCHEDULE

1.4 PROGRAM ORGANIZATION

The program functional responsibilities were organized as shown in Figure 1-3.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CALEB V. SWANSON
SYSTEM TESTS
GARY M. WILSON
PERFORMANCE INDEX ANALYSIS
LAWRENCE L. MOORE
886

Figure 1-3. PROGRAM ORGANIZATION STRUCTURE

SECTION 2
RETROFIT METHOD SURVEY

This survey was the initial task of the program and the one on which the scope and magnitude of program results depended. The extent to which existing retrofit devices could be found and the amount of data obtainable from developers or producers of these devices were key program dependencies. The amount of data obtainable was a direct determinant as to how much more data had to be developed through test and analysis. When the data obtainable were not sufficient either to justify testing or to support analysis, only limited evaluation of the retrofit device was possible.

2.1 SURVEY APPROACH

The retrofit method data survey plan was to search all reliable sources of available information, in order to assemble as much relevant information as possible on retrofit emission control techniques existing for light-duty vehicles.(1) The constraints applied to this information survey encompassed present and potential emission control retrofit methods applicable to pre-1971 motor vehicles in the light-duty gasoline-powered class. The approach to the survey consisted of the following steps.

a. Identifying the sources of retrofit devices.

b. Transmitting a letter of inquiry to these sources, requesting their participation in the program or identification of other retrofit device sources.

c. Transmitting a data questionnaire to interested sources to obtain detailed information about the technical and cost characteristics of their respective retrofit devices.

d. Receipt and recording of data questionnaire responses.

2.1.1 Identification of Retrofit Method Sources

Identification of retrofit method sources required two types of contact. First, direct contact by letter of inquiry was made with known developers and producers. Second, the identification of other sources was requested (also by letter of inquiry) from all organizations and agencies which could conceivably know about or be in contact with developers or producers. Accordingly, two types of introductory letters describing the scope of the program and its sponsor were mailed. One requested only the identification of possible sources and the other, mailed directly to known developers or producers, requested an expression of their intent to participate and to provide followon information about their device. These letters are shown in Appendix A and B, respectively.

---

(1)Under 6,001 pounds gross vehicle weight, as defined in Volume II, Section 1.

The Air Pollution Control Association Directory and the Society of Automotive Engineers (SAE) Roster were used initially to identify sources. Additional source identifications were made utilizing:

a. Environmental Protection Agency (EPA) files

b. California Air Resources Board (ARB) files

c. Olson Laboratories files

d. Inquiry to air quality agencies at Federal and State levels.

e. A patent search conducted through the Northrop Legal Staff

f. A general news release

The news release was issued through Brewer Associates, Dearborn, Michigan, for publication by the nationwide news media shown in Table 2-1. The release appeared in•the newspapers and automotive periodicals noted.

As sources were identified, the Appendix B inquiry letter was mailed to introduce them to the program and request their participation. If the source was interested in the program, his participation was coordinated as follows:

a. By the letter of inquiry, the source was requested to submit his candidacy by sending a letter of intent to participate within two weeks of his receipt of the inquiry letter.

b. With his letter of intent, the candidate was requested to submit product brochures or other descriptive data and any emission test data which would demonstrate the development status of the specific retrofit device or system to be evaluated.

c. Item b. response was evaluated to verify the candidate as a viable developer or producer; and if this was affirmed, then the detailed retrofit data questionaire was mailed.

d. In the questionnaire cover letter, the candidate was requested to complete and return the questionnaire form to Olson Laboratories within two weeks of receipt.

2.1.2 Data Questionnaire

Since the initial response provided by Item b. above, in most cases, did not contain sufficient data or a consistent baseline of device information, a data questionnaire was developed to provide the necessary data in a common format. This questionnaire was mailed to all viable candidates for participation in the program. The questionnaire and the transmittal cover letter are shown in Appendix D.

Table 2-1. RETROFIT METHOD PROGRAM NEWS RELEASE MAILING LIST

Item	Publication	Type		Issue Date
		Magazine	Newspaper	
1.	Atlantic Constitution	X		
2.	Automotive Engineering	X		
3.	Automotive Industries (1)	X		8-15-71
4.	Automotive News (1)	X		9-20-71
5.	Autoproducts	X		
6.	Boston Globe		X	
7.	Business Week	X		
8.	Chicago Tribune		X	
9.	Cleveland Plain Dealer	X		
10.	Denver Post		X	
11.	Design News (1)	X		10-4-71
12.	Detroit Free Press		X	
13.	Detroit News		X	
14.	Houston Post		X	
15.	Los Angeles Times		X	
16.	Machine Design	X		
17.	New York Times		X	
18.	Northrop News (1)		X	9-10-71
19.	Philadelphia Inquirer		X	
20.	Pollution Engineering	X		
21.	Pollution Equipment News	X		
22.	Product Engineering	X		
23.	San Francisco Chronicle			
24.	Wall Street Journal			
25.	Washington Post			

(1) Publication known to have published the Retrofit Method Program News Release. No response was received from the other publications.

The questionnaire was designed so as to elicit from the retrofit method developer or producer, the full scope and depth of information required to perform a comprehensive system analysis and evaluation on the device submitted. Ideally, the completeness of the questionnaire response would preclude the need for testing. The questionnaire was structured to provide qualitative and quantitative data in the following categories:

a. System Information - Including system technical description, development emission control category, and vehicle adaptability.

b. Performance Data - Including emission reduction, reliability, maintainability, and driveability.

c. Cost Data - Including initial and recurring costs.

The format of the information survey was organized to permit the data information to be applied directly to the screening evaluation and the cost-effectiveness analysis.

2.2 RECORDING SYSTEM

As responses to the letter of inquiry (Appendix B) were received, each was assigned a file number for control purposes. This was done whether or not the respondee desired to participate, since the record of negative contacts would be of use in future programs to preclude duplicate, unnecessary effort.

Each response was reviewed to determine the nature of the response and the adequacy of data. The results of this review were recorded on the form shown in Figure 2-1.

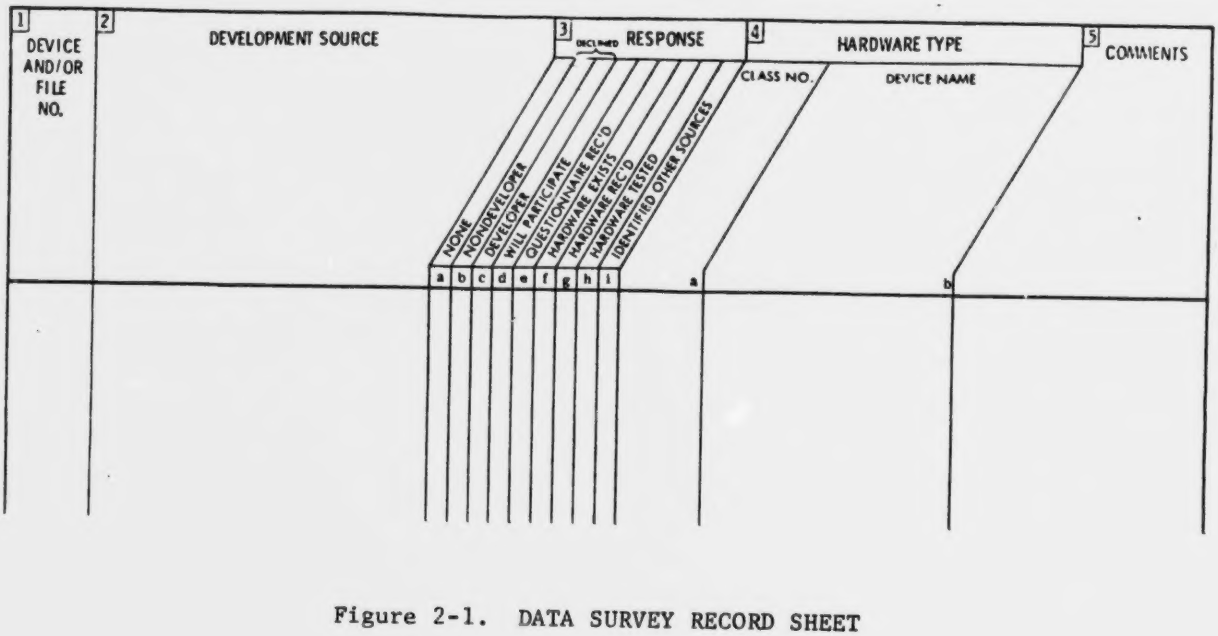

1
DEVICE AND/OR FILE NO.
2
DEVELOPMENT SOURCE
3
DECLINED
RESPONSE
NONE
NONDEVELOPER
DEVELOPER
WILL PARTICIPATE
QUESTIONNAIRE REC'D
HARDWARE EXISTS
HARDWARE REC'D
HARDWARE TESTED
IDENTIFIED OTHER SOURCES
a
b
c
d
e
f
g
h
i
4
HARDWARE TYPE
CLASS NO.
DEVICE NAME
a
b
5
COMMENTS

Figure 2-1. DATA SURVEY RECORD SHEET

This form provided the following categorization of the response.

a. No response to letter of inquiry

b. Responded to letter of inquiry, but declined participation on basis of being a nondeveloper.

c. Responded but declined participation even though a developer.

d. Responded and will participate.

e. Returned questionnaire filled out.

f. Has existing retrofit hardware.

g. Has submitted hardware.

h. Hardware is to be tested.

i. Identified other development sources.

These fields of information were tabulated so that a profile of the retrofit development field could be established. From this profile the state of retrofit technology was evaluated, as documented in Volume II, Section 1.

Based on the review of data questionnaires which the recording form identified, those retrofit devices having sufficient data for evaluation were identified. These devices became the basis for the system analysis effort and the supporting test program.

2.3 RETROFIT METHOD CLASSIFICATION SYSTEM

To catalog the variety of retrofit devices for which data were received, the classification system shown in Table 2-2 was devised. This system groups all devices by four basic generic emission control system groups according to emission source: (1) exhaust, (2) crankcase blowby, (3) fuel evaporation, and (4) combinations of these groups. Each group is subdivided according to major types and, when further subordination is required, by subtype. As mentioned, at the group level, classification is by emission source. At the type level, classification is by physical location or functional interface of the control technique; for example, exhaust system, induction system, ignition system, and within the cylinder itself, as for fuel additives. At the subtype level, classification is by specific control function.

When a retrofit was found to combine two or more of the control functions within a group, the device was arbitrarily categorized as part of a retrofit type or subtype within that group, rather than as a Group 4 combination device. In general, such combinations were classified according to the major type of retrofit hardware required. Group 4 was reserved for devices combining two or more group level control functions.

Table 2-2. CLASSIFICATION OF RETROFIT METHODS

GROUP	TYPE	SUBTYPE	TITLE
1			EXHAUST EMISSION CONTROL SYSTEMS
	1.1		Exhaust Gas Control Systems
		1.1.1	Catalytic Converter
		1.1.2	Thermal Reactor
		1.1.3	Exhaust Gas Afterburner
		1.1.4	Exhaust Gas Filter
		1.1.5	Exhaust Gas Backpressure
	1.2		Induction Control Systems
		1.2.1	Air Bleed to Intake Manifold
		1.2.2	Exhaust Gas Recirculation
		1.2.3	Intake Manifold Modification
		1.2.4	Carburetor Modification
		1.2.5	Turbocharger
		1.2.6	Fuel Injection
	1.3		Ignition Control Systems
		1.3.1	Ignition Timing Modification
		1.3.2	Ignition Spark Modification
	1.4		Fuel Modification
		1.4.1	Alternative Fuel Conversion
		1.4.2	Fuel Additive
		1.4.3	Fuel Conditioner
2			CRANKCASE EMISSION CONTROL SYSTEMS
	2.1		Closed System
	2.2		Open System
3			EVAPORATIVE EMISSION CONTROL SYSTEMS
	3.1		Crankcase Storage
	3.2		Canister Storage
4			EMISSION CONTROL COMBINATIONS

SECTION 3
SYSTEM TESTS

The retrofit system test program was the means of establishing a set of emissions test data and vehicle performance data for a range of retrofit devices, with a common baseline of test vehicles and test procedures. The basic ground rule for these system tests was that, when the obtainable information was inadequate to provide the retrofit system information required by Contract Exhibit A, Section III-C, experimentation would be undertaken to provide at least a minimum of emissions data, if the particular system justified the effort. To provide valid comparison of such systems, all were tested by the 1972 Federal Test Procedure.(1)

Testing was performed at Olson Laboratories vehicle emission test facilities at Taylor, Michigan, and Anaheim, California. Both facilities were equipped for vehicle exhaust measurements in the volumetric and mass concentrations for 7-mode and constant volume sampling (CVS) test procedures. Replicate vehicle fleets (i.e., fleets with cars of the same make, model year, cubic inch displacement, and running gear configuration) were maintained and operated at each facility for testing of the retrofit systems.

The policy followed in the test program was to test, within the constraints of time and money, as many as possible of those retrofit devices found by screening evaluation to offer a reasonably cost effective reduction in vehicle emissions. The program requirement (Contract Exhibit B) was to test six different retrofit devices on six vehicles at the Anaheim facility and on six replicate vehicles at the Taylor facility, each to a prescribed set of procedures encompassing emissions and driveability tests with and without the device installed. Four of these devices were to be tested to evaluate their durability.

To determine which six retrofit devices should be subjected to the replicate vehicle tests, the prescribed set of emissions and driveability tests was performed on nine different devices, with each installed on two different test vehicles; and on two different devices, with each installed on one vehicle. From these screening tests, it was determined tha only four devices should be subjected to the full scope of a six-car replicate test vehicle fleet test program. This determination was based on the relatively greater emission reductions of the four devices and also on the tight schedules within which the tests would have to be performed.

---

(1)As defined in the Code of Federal Regulations: Title 45, Public Welfare; Chapter XII, Environmental Protective Agency; Part 1201, Control of Air Pollution from New Motor Vehicles and New Motor Vehicle Engines. The test procedure used was published in Federal Register Volume 35, No. 219, Part II, dated 10 November 1970. This procedure was reassigned to the aforementioned CFR by Federal Register Volume 35, No. 245, dated 18 December 1970. The test procedure for No_x evaluation was published subsequently in Federal Register Volume 36, No. 128, Part II, dated 2 July 1971.

The overall test program approach encompassed the following steps:

a. Identify candidate retrofit systems for test

b. Procure test vehicles

c. Calibrate test instrumentation systems

d. Perform emission and driveability baseline tests on vehicles

e. Perform emissions and driveability tests on retrofit systems installed

f. Perform durability tests

3.1 IDENTIFICATION OF CANDIDATE RETROFIT SYSTEMS FOR TEST

The amount of time available for testing required that the initial screening of candidate devices to be tested begin prior to receiving all information from the developers and producers participating in the program. The information obtained from each source that responded favorably was reviewed to identify the device category, level and reliability of emission reduction, availability of device for testing, and cost, as well as the adequacy of data by which to perform a complete system analysis of the device. This information was tabulated for each device, to establish an overall ranking of devices. Devices were identified as test candidates by obtaining a high overall ranking; these were then reviewed and candidates were approved by mutual consensus of Technical Review Board Members. The test candidate devices were identified on the basis of their representativeness of the generic retrofit groups, on average emission reduction potential, and on weighted development status and initial costs.

The procedure to select the candidate retrofit devices for laboratory evaluation was established at the 10 September 1971 Technical Review Board Meeting. The devices were ranked by their average percentage emission reduction. A tabulation was made, including the following items:

a. Device file number

b. Average percentage emission reduction

c. Development status of test hardware

d. Initial cost

e. Retrofit Method Classification

f. Sufficiency of data provided by questionnaire response.

The percentage emission reduction and weighted ratings were established as follows:

a. Emission Reduction Percent Change: Average percentage of emission reduction from baseline was calculated as follows:

$$\text{Percentage Reduction} = \frac{1}{3} \quad (\%\text{HC reduction} + \%\text{CO reduction} + \%\text{NOx reduction})$$

In cases of multiple sets of data provided by the retrofit device source, the best test data was used. These data were coded to indicate the type and extent of test (cold-start, hot-start, baseline, and idle tests).

b. Development Status: Codes for development status were based on the readiness of the device for quantity production:

Code	
1	Marketed currently
2	Prototype stage
3	Development stage
4	Unknown status.

c. Cost: Since most of the file data lacked cost information, cost estimates were based on device complexity. Codes for cost brackets were established as follows:

Code	
1	Less than \$100
2	Between \$100 and \$300
3	Over \$300
4	Not available.

3.2 TEST VEHICLE SELECTION

In accordance with Contract 68-04-0038, Exhibit B, a pool of 24 test vehicles could be purchased and maintained for use in testing the retrofit devices installed on the vehicles against the standard (baseline) vehicle configuration without the devices installed. Replicate vehicle fleets were established at the test facility in Anaheim, California, and at the Taylor, Michigan, facility. The selection criteria for the test vehicle fleet were:

a. Number of light duty (6,000 pounds and less gross vehicle weight) vehicles on the road by model year and make prior to 1968

b. Popularity of engine and transmission combinations within that vehicle population.

c. No emission control devices originally installed.

d. Value of the automobile

Since exhaust controls were incorporated nationally on 1968 vehicles, the total vehicle population of concern was restricted to pre-1968 cars, to obtain a vehicle fleet without factory installed emission controls. The total number of candidate test vehicles was based on data provided in "Automotive News, 1971 Almanac," dated 26 April 1971. The number given for pre-1968 passenger cars in U.S. operation was reduced by the percentage of 1966 and 1967 vehicles originally sold in California with exhaust control devices (this eliminated vehicles with factory installed exhaust control devices sold in California beginning in 1966). This reduced total figure was then further reduced based on pre-1968 cars scrapped from 1 July 1970, as given in the aforementioned document, to 1 July 1971, by applying scrappage rates given in the publication. Excerpts from these statistics are presented below:

Model Year	Number of Vehicles (1)
Pre-1963	13,057,674
1963 - 1965	14,164,787(2)
1966 - 1967	14,433,406(2)

NOTES: (1) Extrapolated from 1 July 1970 to 1 July 1971 "Automotive News" (1971 Almanac Issue).

(2) Number of 1963-67 vehicles does not include vehicles sold new in California.

As shown by this table, the total population of concern is divided almost evenly among the model year blocks listed. To minimize emission level variations attributable to different model years - and because of the small size of the test fleet and the range of makes and model years to be covered, it was decided to choose a single model year to represent each of two classes of vehicles: those with no devices at all and those with positive crankcase ventilation (PCV) devices only. These classes are pre-1963 and 1963-1967 vehicles, respectively (excluding vehicles sold new in California).

Due to the low dollar value of cars in the pre-1963 category, the installation of exhaust control devices becomes hard to justify economically. Because of this, only one car with no device was chosen for the test vehicle fleet. The most representative car in this category, based on extrapolated statistics, was a 1961 Chevrolet with a 283 CID V-8 engine. Adequate data obtained on blowby devices precluded the need for testing these devices. Therefore, the 1961 vehicle was used for exhaust emission control retrofit device testing.

Originally, the Plan of Performance (dated 30 July 1971) specified that 1966 vehicles without factory installed exhaust control devices be purchased both in Anaheim and Detroit since California cars sold in 1966 were equipped with exhaust control devices. This meant that out-of-state vehicles would have to be bought for the California fleet. Approximately 10 man days were expended to locate the out-of-state 1966 model cars in the Anaheim area, which produced only one without an exhaust device. At least 80 dealers were contacted in the Orange and San Bernardino County areas. Contacts were also made with three dealers in Phoenix, Arizona, with negative results. Because of the expense and the contract time constraints to acquire the remainder of the 1966 test vehicles, it was agreed with EPA Project Officer to change the year model from 1966 to 1965 for both the Anaheim and Detroit fleets.

The vehicles finally chosen represented the popularity of makes, models and engine sizes, and the availability of vehicles. One vehicle to be acquired was a 1965 Ford station wagon with 390-cubic-inch displacement engine. As the 1965 model year fleet was being purchased, it became apparent that 1965 Ford station wagons were more often equipped with 352 CID engines. During the vehicle acquisition search, none with 390 CID was located. Only a few 1965 Ford sedans (Galaxies and LTDs) had 390-CID engines. Consequently, the EPA Project Officer agreed to modify the original list to include Ford sedans with 390-CID engines instead of the station wagon. The major criteria of the 390 CID engine remained unchanged. The Galaxie sedan weighs 330 pounds less than the station wagon.

The unweighted averages for the engine displacements in the chosen sample compares favorably with the unweighted averages of displacements sold new in the years 1961 and 1965 ("Automotive Industries," 52nd Annual Engineering Specifications and Statistical Issue, March 15, 1970). These are 283 versus 277 and 311 versus 320 CID, respectively.

In summary, the test fleet acquired was as shown in Table 3-1. Cars 7 and 13 (1965 Chevrolet 194 with standard transmission) were not purchased because none of that type was available for purchase within the time frame of the test program. Cars 19 and 20 were Volkswagens (VW's), which were used for foreign car retrofit device testing. Device Nos. 1 and 246 were tested on VW's at the Anaheim and Taylor facilities.

3.2.1 Test Vehicle Selection Screening

As part of the acquisition process, each vehicle received a three-step inspection prior to being accepted for purchase: (1) overall vehicle inspection; (2) engine condition; (3) emission measurements.

Figure 3-1 shows the form used to record vehicle condition in this screening process.

Figure 3-2 shows some of the test vehicles which were used in the retrofit program.

The initial vehicle inspection was a visual check of lights, tires, brakes, transmission, muffler, and other chassis components. The car was driven to check wheel balance and transmission shift patterns. Appropriate remarks were entered in the Figure 3-1 form. In addition, all vehicles were initially inspected for assurance of standard equipment as supplied by the car manufacturer, with respect to tires and running gear components.

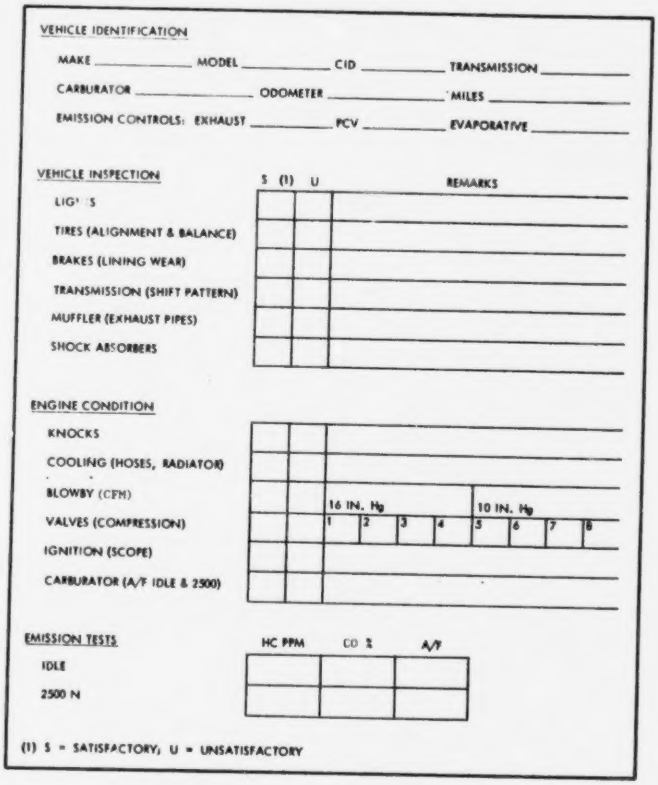
Table 3-1. TEST VEHICLE FLEET (1)

Location	Car Number (Fleet)	Year	Make	Model	Engine Size		Transmission	As Received Odometer Miles	Carburetor (Model and Number)
					CID	Class			
Anaheim	1	65	Chevrolet	Nova	194	B	Standard	12,053	Rochester IV 7025105
Anaheim	2	65	Ford	Fairlane	289	D	Automatic	62,224	Autolite 2V C52F-9510-B
Anaheim	3	65	Plymouth	Fury	318	E	Automatic	84,054	Carter 2V BBD 38445
Anaheim	4 (2)	65	Chevrolet	Impala	327	E	Automatic	82,245	Rochester 4V 4CC 7025122
Anaheim	5	65	Ford	LTD	390	F	Automatic	92,124	Autolite 4V C5AF-9510-AC
Anaheim	6	61	Chevrolet	Impala	283	D	Automatic	114,070	Rochester 2V 2GC 7019008
Taylor	7 (3)	65	Chevrolet	Nova	194	B	Standard		
Taylor	8	65	Ford	Fairlane	289	D	Automatic	38,343	Ford 2V C5ZEH
Taylor	9	65	Plymouth	Fury III	318	E	Automatic	45,576	Carter 2V 38485A-5
Taylor	10	65	Chevrolet	Impala	327	E	Automatic	56,300	Carter 4V AFB 3721-SB-HC
Taylor	11	65	Ford	Galaxie	390	F	Automatic	49,560	Ford 4V C5AF-H A-4GB
Taylor	12	61	Chevrolet	Impala	283	D	Automatic	45,120	Rochester 2V
Anaheim	13 (3)	65	Chevrolet	Nova	194	B	Standard		
Taylor	14	65	Ford	Fairlane	289	D	Automatic	55,601	Ford 2V C5ZFH
Taylor	15	65	Plymouth	Fury	318	E	Automatic	103,895	Bendix 2V WW 3-251-A
Taylor	16	65	Chevrolet	Impala	327	E	Automatic	100,207	Rochester 4V 7025121
Anaheim	17 (2)	65	Ford	Galaxie	390	F	Automatic	57,119	Autolite 4V C5AF-9510-AC
Anaheim	18 (2)	61	Chevrolet	Impala	283	D	Automatic	82,833	Rochester 2V 2GC 7019008
Anaheim	19	65	VW	1500	91	A	Standard	89,224	Solex 28 PICT-1
Taylor	20	65	VW	1500	91	A	Standard	65,154	Solex 28 PICT-1 13, 129, 023H
Anaheim	21 (2)	65	Chevrolet	Impala	327	E	Automatic	62,552	Rochester 4V 4GC 7025122
Anaheim	22 (2)	65	Chevrolet	Super Sport	327	E	Automatic	92,313	Rochester 4V 4GC 7025121

(1) All vehicles were initially inspected for assurance of standard equipment as supplied by the automobile manufacturers (tires, running gear components, etc.).

(2) Durability test vehicles.

(3) Cars, numbers 7 and 13, were not purchased.



VEHICLE IDENTIFICATION

MAKE ____________ MODEL ____________ CID ____________ TRANSMISSION ____________

CARBURATOR ______________ ODOMETER ______________ MILES ______________

EMISSION CONTROLS: EXHAUST ____________ PCV ____________ EVAPORATIVE ____________

VEHICLE INSPECTION

	S (1)	U	REMARKS
LIGHTS			
TIRES (ALIGNMENT & BALANCE)			
BRAKES (LINING WEAR)			
TRANSMISSION (SHIFT PATTERN)			
MUFFLER (EXHAUST PIPES)			
SHOCK ABSORBERS			

ENGINE CONDITION

KNOCKS										
COOLING (HOSES, RADIATOR)										
BLOWBY (CFM)			16 IN. Hg				10 IN. Hg			
VALVES (COMPRESSION)			1	2	3	4	5	6	7	8
IGNITION (SCOPE)										
CARBURATOR (A/F IDLE & 2500)										

EMISSION TESTS

	HC PPM	CO %	A/F
IDLE			
2500 N			

(1) S = SATISFACTORY; U = UNSATISFACTORY

Figure 3-1. TEST VEHICLE PROCUREMENT SCREENING DATA SHEET

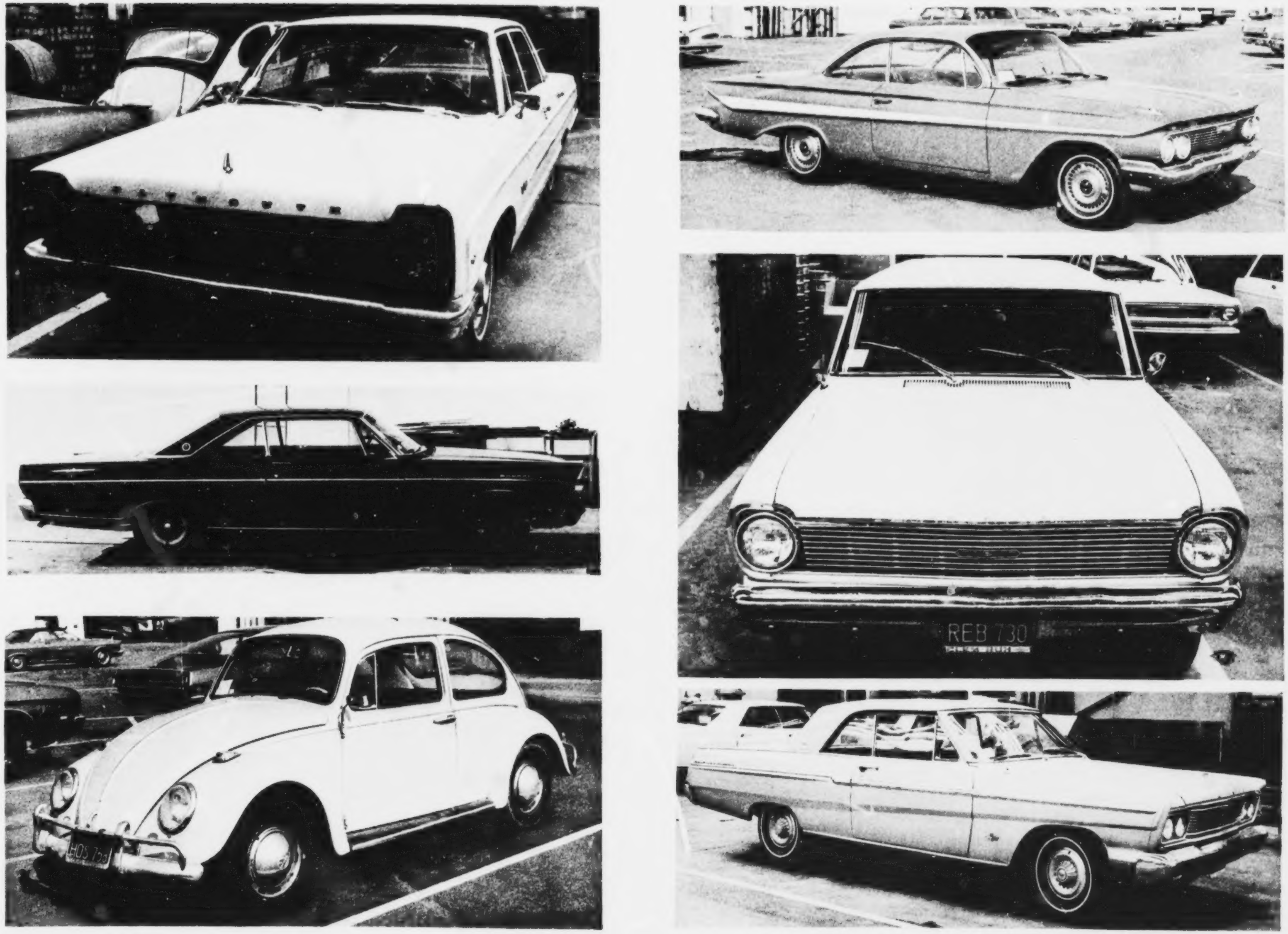


Figure 3-2. REPRESENTATIVE TEST VEHICLES

If the vehicle passed the initial inspection, it received an engine condition inspection. The engine was diagnosed for knocks and cooling system condition. Ring wear was determined by measuring crankcase blowby and comparing this to the flow of the average vehicle (California Blowby Device Test Procedures as shown in Appendix F). The valve wear was determined by both a power drop test (scope) and a compression check. The condition of the ignition system was diagnosed with a scope; however, ignition condition was not a criterion of acceptability.

Following the engine condition inspection, the car received an idle emission and a 2,500-rpm (neutral gear) emission test. Both HC and CO were measured. Carburetion performance was diagnosed for power circuit failures with the emission test data. The emission tests provided further diagnoses for tuneup as discussed in paragraph 3.2.2.

3.2.2 Test Vehicle Baseline Test and Tuneup

Following selection as an acceptable test vehicle, each car was checked for its as-received exhaust emission level and driveability. The initial emission test was performed by the Federal 7-mode hot-start procedure to establish the emission level relationship of the vehicle "as received" with the existing emission data bank. (1) Next, the vehicle was tested in accordance with the 1972 Federal Test Procedure. (2) The car then was serviced and tuned in accordance with the manufacturer's specifications, using the procedure outlined in Table 3-2. Emission and driveability baseline testing was then performed to establish the baseline vehicle performance for the 1972 Federal Test Procedure.

Table 3-2. RETROFIT TEST VEHICLE SERVICE AND TUNEUP PROCEDURE

1.0 Services Performed During As-Received Tests

1.1 Lube, change oil and filter after all as-received tests
1.2 Repair minor defects on fleet, if necessary
  - wheel balance
  - muffler leaks (conducted prior to as-received tests)
1.3 Conduct as received driveability tests (note choke problems)
1.4 Identify cars by location, project number and car number (see Table 3-1)

2.0 Required Services Between As-Received and Baseline Tests

2.1 Purchase tuneup parts
  - plugs, points and condenser for all cars
  - carburetor gasket kits (as required by diagnosis)

---

(1) This initial exhaust emission test, required by Contract Exhibit B to compare the as-received vehicle emissions against existing historical emission data for similar vehicles (7-mode data is the most predominant) was performed in accordance with the 1970 Federal Test Procedure as defined in Federal Register Volume 33, Number 108, dated 4 June 1968. Driveability testing was performed in accordance with the procedure described in paragraph 3.4.

(2) Federal Register Volume 35, No. 219, dated 10 November 1970.

Table 3-2. RETROFIT TEST VEHICLE SERVICE AND TUNEUP PROCEDURE (CONT)

2.2 Conduct tuneup on all cars
  - install plugs, points and condenser (for quality, use scope to audit tuneup)
  - check ignition advance curve - set to specifications
  - clean PCV system (inspect hoses and carburetor base plates)
  - clean carburetor (diagnose emissions at idle and 2,500 rpm to determine need for cleaning)
  - check choke operation when cold
  - check choke relief after starting
  - check fast idle operation
  - set all adjustments to car manufacturer's specifications
  - set idle air-fuel ratio to best idle if mixture is not specified (record idle CO after adjustment for future baseline tests)
  - do not tune for lowest emissions

2.3 Conduct after tuneup driveability test
  - note and compare to as-received driveability test

NOTE: Tuneup criteria were those established by the manufacturer's specifications, without consideration of achieving low exhaust emissions.

3.3 RETROFIT DEVICE EMISSION TESTS

In accordance with the requirement of Contract 68-04-0038, Exhibit B, emissions, fuel consumption, driveability, and safety tests were to be performed on six different retrofit devices, using 12 identical specimens of each device on two fleets of replicate test vehicles - six from the Anaheim and Taylor fleets, respectively. Four retrofit systems were selected by the Technical Review Board for evaluation on 13 fleet vehicles and ten were selected for evaluation on two vehicles. The ten devices were tested first to identify those worthy of further test. The scope of tests was the same on all devices. Tests on the ten devices were performed to the following ground rules:

a. Screening tests were to be conducted at Anaheim only.

b. The devices were to be tested on one car by the 1972 Federal Test Procedure and the emission results compared to the baseline vehicle emission test without the device. If the results showed a 20 percent emission reduction, a second test, with the device installed on a different vehicle, was to be performed to confirm the first test. The results of the second test was to be compared to the baseline tests of the second vehicle. Fuel consumption was to be measured during the Constant Volume Sampler (CVS) tests. Driveability tests were to be conducted after the CVS exhaust tests, provided the device showed a 20 percent emission reduction.

c. The 1965 Chevrolet 327 and the 1961 Chevrolet 283 were to be used as the test vehicles if devices were available for these cars. Alternate fleet cars were to be used only if devices could not be obtained on a schedule compatible with the test schedule for the two Chevrolets.

Tests of the four devices selected for 13-car tests each took five consecutive days to complete, as follows:

a. Day 1: Remove previously tested retrofit system and restore vehicle to car manufacturer's specifications.

b. Day 2: Conduct baseline driveability test

c. Day 3: Conduct baseline CVS emission test

d. Day 4: Install retrofit device and adjust

e. Day 5: Conduct retrofit CVS emission test

f. Day 6: Conduct retrofit driveability test; remove device (Day 1)

Figure 3-3 illustrates the test sequence. An average of four evaluations on four cars were conducted each week at each test center. There were two constraints which limited the number of evaluations:

a. Device installation: Some devices took up to 2.5 hours to install. One device took approximately 4 hours.

b. Driveability: The AMA driveability procedures took about 2.5 hours to complete, including setup time.

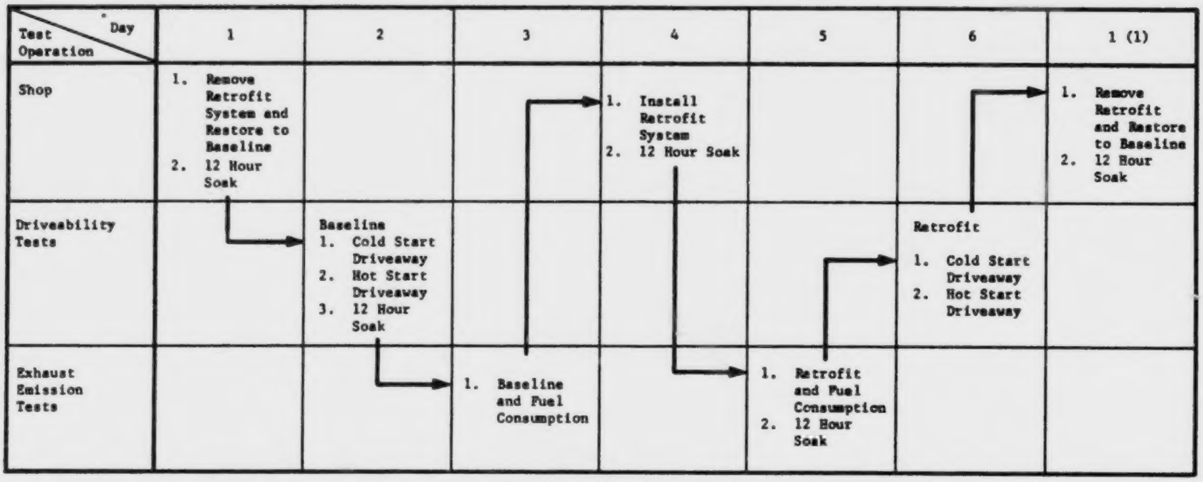
In preparing for all retrofit device tests, the retrofit device developer or producer either made or monitored the installation of his device on the test vehicle and was invited to view the tests. Installation time was recorded, as well as the developer's tuneup adjustments for the device.

Each test vehicle received a baseline evaluation without a device installed prior to having the next retrofit device installed. In the event that baseline test data varied, as might be caused by a particular retrofit device installation, these new baseline data were used for comparison with the emission and driveability data of the next retrofit device.

3.4 DRIVEABILITY TESTS

Basic driveability tests were conducted on each of the 11 retrofit devices tested, in accordance with the AMA Driveability Test Procedure shown in Appendix G. Baseline driveability tests were conducted prior to device installation on a vehicle and after the device was installed (refer to Figure 3-3).

In addition to these driveability tests, vehicle operational driveability tests were performed under desert and mountain environments. These tests were performed on each of the four retrofit systems tested on 13 vehicles. The tests were conducted on replicate Vehicle No. 17 (Ford 390) out of the Anaheim test center. This vehicle



Test Operation / Day	1	2	3	4	5	6	1 (1)
Shop	1. Remove Retrofit System and Restore to Baseline 2. 12 Hour Soak			1. Install Retrofit System 2. 12 Hour Soak			1. Remove Retrofit and Restore to Baseline 2. 12 Hour Soak
Driveability Tests		Baseline 1. Cold Start Driveaway 2. Hot Start Driveaway 3. 12 Hour Soak				Retrofit 1. Cold Start Driveaway 2. Hot Start Driveaway	
Exhaust Emission Tests			1. Baseline and Fuel Consumption		1. Retrofit and Fuel Consumption 2. 12 Hour Soak		

(1) Six day test sequence starts over for the next scheduled retrofit device.

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Figure 3-3. BASELINE AND RETROFIT SYSTEM TEST SEQUENCE FOR EACH TEST VEHICLE

was most convenient for these tests because it was not scheduled for device tests during the remainder of the test schedule. The car was tested once for baseline mountain and desert driveability before the system tests. The installed devices were tested by the procedures below.

a. Mountain driving was conducted by driving the device-equipped vehicle up to 8,000-foot altitudes, and parking overnight at the 6,500-foot level (Big Bear, California). The following morning, a cold-start driveaway evaluation was conducted by the AMA driveability procedure. Ambient temperature was recorded.

b. Desert driving followed the same day by proceeding to the Mojave Desert (Victorville, California), and then back to the test center at Anaheim. One hot-start driveability evaluation was conducted by the AMA driveability procedure. Ambient temperature was recorded. Any tendency to vapor lock during this test was recorded.

Additional performance tests were conducted on all baseline and retrofit AMA driveability tests by measuring wide open throttle acceleration times from 0-60 mph.

Vehicle performance degradations during each driveability test was rated according to the magnitude of the problem. The degrees of degradation were trace, moderate, and heavy. These were defined as follows:

a. Trace: Driver can detect slight loss of vehicle performance, but car can still be operated without threat of power failure.

b. Moderate: Driver can detect noticeable loss of vehicle performance, but car can still be operated without threat of complete power failure.

c. Heavy: Driver can detect unreliable and unsafe vehicle performance; car may be operable, but service is required.

Driveability tests were performed at prescribed areas near the Anaheim and Taylor test facilities.

3.5 DURABILITY TESTS

Durability tests were conducted on five test vehicles at the Anaheim test facility. Each car was driven 25,000 miles with retrofit exhaust emission tests conducted at 0, 5,000, 10,000, 15,000, 20,000, and 25,000-mile intervals. The exhaust emission evaluation was conducted by means of the cold-start 1972 Federal Test Procedure. The durability test vehicles were prepared as follows:

a. Tuneup in accordance with manufacturer's specifications and repair as necessary for 25,000 miles, including lube, oil change, and filter change.

b. Baseline CVS tests after tuneup (fuel consumption measurement included).

c. Device installed and adjusted to developer's specifications.

d. 0-mile CVS test with device installed (fuel consumption measurement included).

e. Accumulate mileage and conduct CVS and fuel consumption tests at 5,000, 10,000, 15,000, 20,000, and 25,000 miles. Drivers fill in Log Sheets.

f. Tuneup at car manufacturer's recommended mileage interval.

g. Lubrication, oil, and filter change at each 5,000-mile test interval prior to cold soak.

If car experienced a mechanical failure, it was stopped. The cause was determined, corrected and recorded on the Log Sheets. If the failure was device oriented, the Project Engineer was advised before continuing with repairs and mileage accumulation. Daily preventive maintenance was performed to preclude failures; this included oil and water level check of the vehicle and general inspection of the device installation for any variations from normal.

The fleet was operated on a 32-mile durability test route which was established in the Anaheim, Fullerton, and Santa Ana areas as shown in Figure 3-4. The test route was patterned after the California Air Resources Board LA-2 durability test route, which contains several types of driving modes as shown in Table 3-3.

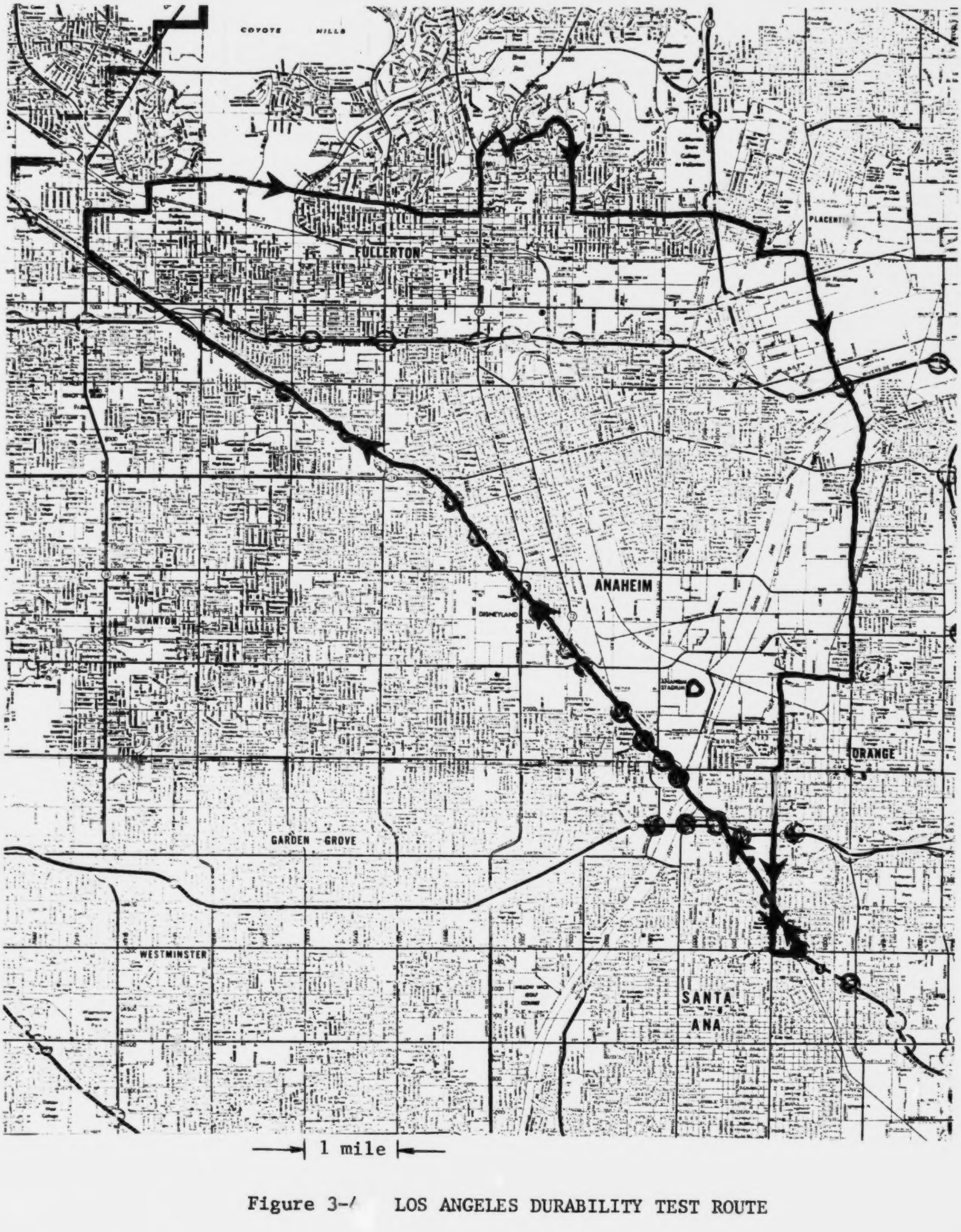

COYOTE HILLS
FULLERTON
PLACENTIA
ANAHEIM
DISNEYLAND
STANTON
ANAHEIM STADIUM
ORANGE
GARDEN GROVE
WESTMINSTER
SANTA ANA
1 mile

Figure 3-1 LOS ANGELES DURABILITY TEST ROUTE

Table 3-3. DURABILITY TEST ROUTE

Driving Mode	Maximum Speed Limit (MPH)	Time in Mode (%)
Freeway (1)	65	30
Suburban	45	40
City	25	15
Residential	35	15
(1) Added to basic test requirement.		

Because of the time limit constraint on this program, the durability test cars were driven on a 100-mile freeway route once each workday. The fleet was operated 3 shifts a day, 7 days a week (6 hours per shift of actual driving time). This rate yielded 500-600 miles per day at an average speed of 35 mph with the schedule shown in Table 3-4.

Table 3-4. DURABILITY TEST MILEAGE ACCUMULATION SCHEDULE

Shift	Time (Hours)	Test Route	Miles	Loops	Total Miles
1	0600-1400	LA-2	32	4	128
		Freeway	100	1	100
2	1400-2200	LA-2	32	4	128
		Freeway	100	1	100
3	2200-0600	LA-2	32	4	128
		Freeway	100	1	100
			Total per 24-hour day: 456		

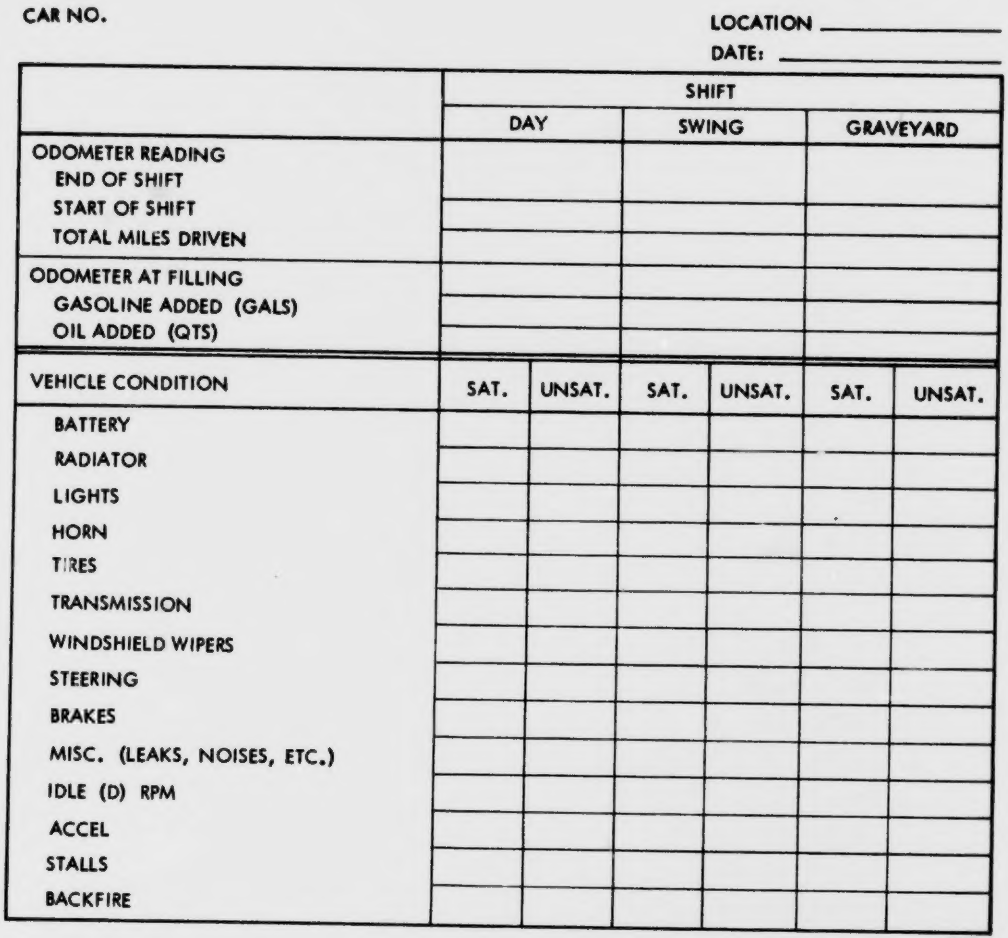
Mileage accumulation and the emission evaluation tests required approximately 10 weeks. This included the time for the emission tests, which required 12 hours of soaktime prior to the cold-start, and time for any vehicle breakdowns (such as tires or brakes). Figure 3-5 shows the daily shift record for the durability test.

3.6 FACILITIES

The existing facilities of Olson Laboratories, Inc., (OLI) and the Northrop Corporation were used in performing the program. The principal facilities consisted of the following:

a. Olson Laboratories vehicle emission test facilities at the Northrop Corporation Electro-Mechanical Division, Anaheim, California. (Figure 3-6)

b. Olson Laboratories vehicle emission test facilities in Taylor, Michigan.



CAR NO.

LOCATION ____________

DATE: ____________

	SHIFT					
	DAY		SWING		GRAVEYARD	
ODOMETER READING END OF SHIFT						
START OF SHIFT						
TOTAL MILES DRIVEN						
ODOMETER AT FILLING						
GASOLINE ADDED (GALS)						
OIL ADDED (QTS)						
VEHICLE CONDITION	SAT.	UNSAT.	SAT.	UNSAT.	SAT.	UNSAT.
BATTERY						
RADIATOR						
LIGHTS						
HORN						
TIRES						
TRANSMISSION						
WINDSHIELD WIPERS						
STEERING						
BRAKES						
MISC. (LEAKS, NOISES, ETC.)						
IDLE (D) RPM						
ACCEL						
STALLS						
BACKFIRE						

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Figure 3-5. DAILY SHIFT RECORD FOR DURABILITY TEST

c. Northrop Corporation data processing facilities at the Corporate Data Processing Center, Hawthorne, California.

d. Paved driveability test area immediately adjacent to the emission test area in Anaheim, Calif. Figure 3-7 shows the overall test area.

The program was headquartered and administered from the Olson facilities at the Northrop Corporation Electro-Mechanical Division. The major part of the analytical effort was performed at the California facility, because of the advantages in computer proximity. The test equipment used on this program was essentially the same at both the Anaheim, California, and the Taylor, Michigan, facilities. The equipment, shown in Figure 3-8, is qualified through EPA calibration procedures and is listed below.

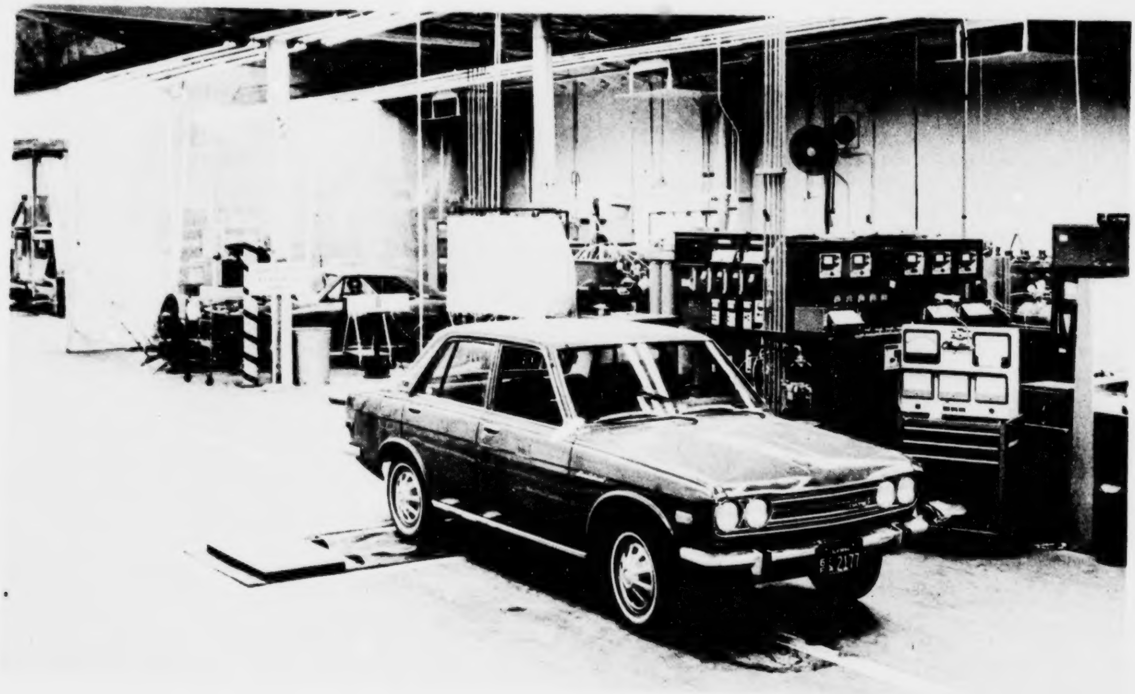


Figure 3-6. VEHICLE EMISSION TEST FACILITY AT ANAHEIM, CALIFORNIA

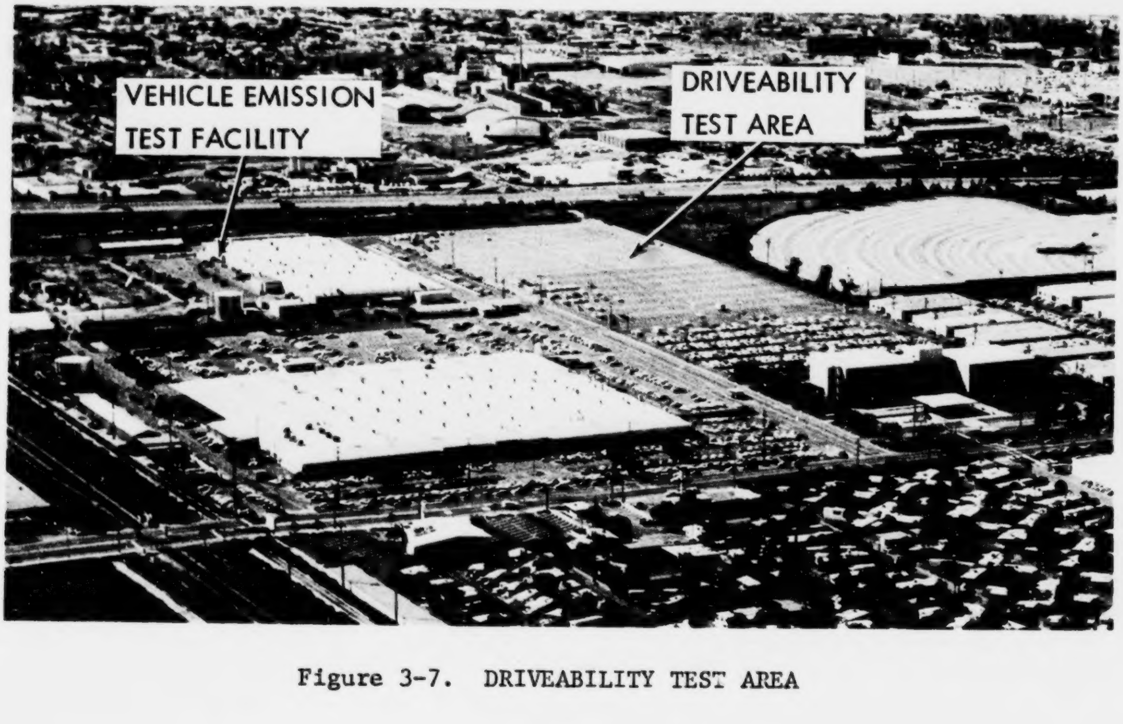
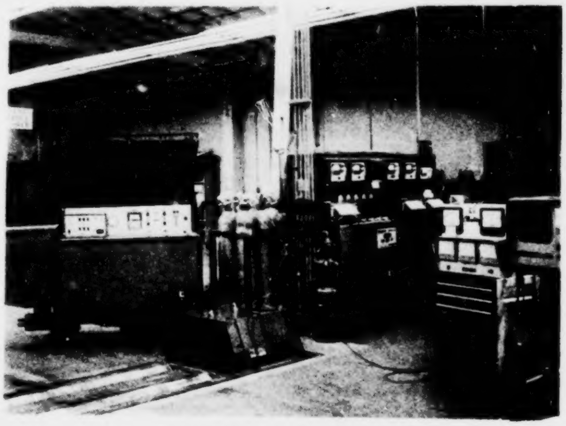
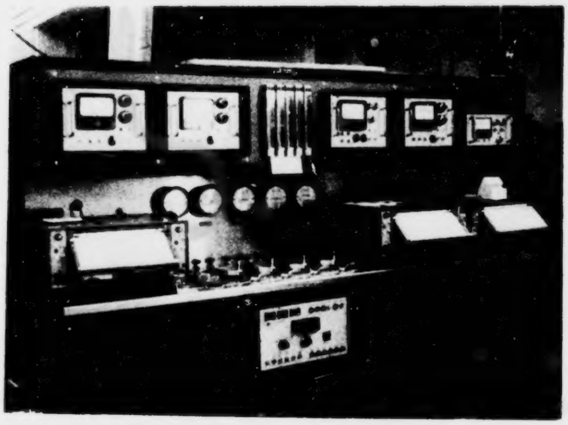

VEHICLE EMISSION TEST FACILITY
DRIVEABILITY TEST AREA

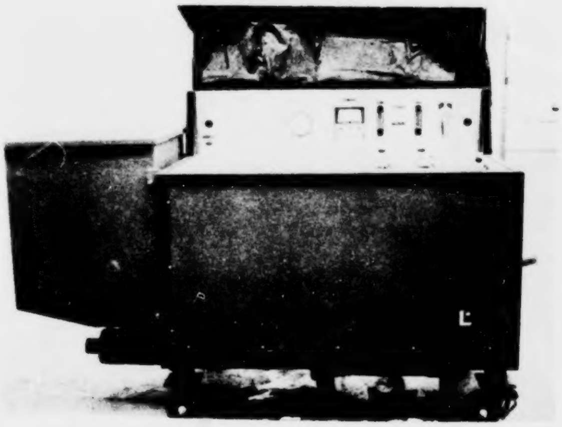
Figure 3-7. DRIVEABILITY TEST AREA



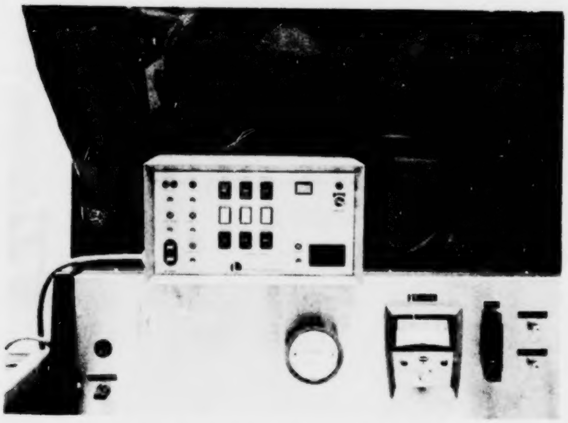
INSTRUMENTATION AND DYNAMOMETER AREA



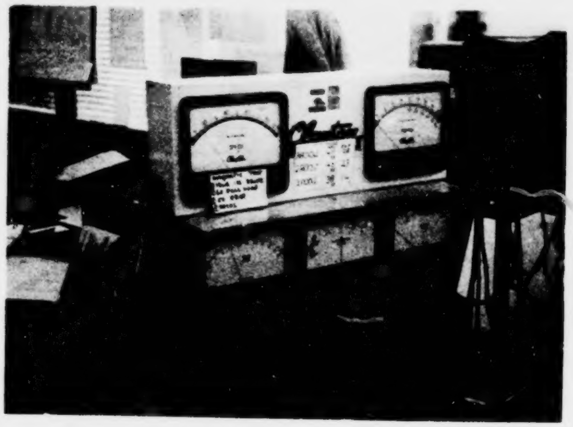
NORTHROP/OLSON LABORATORIES GAS ANALYZER



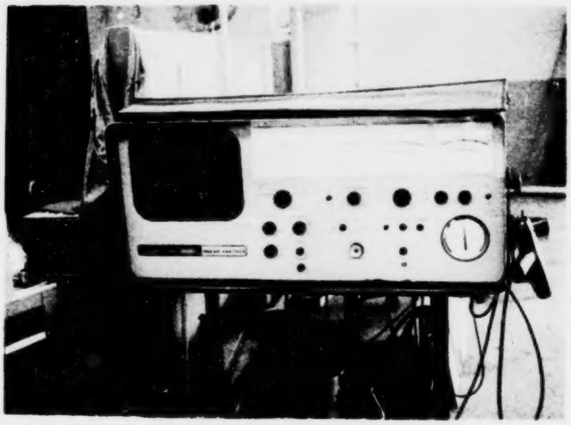
NORTHROP/OLSON CONSTANT VOLUME SAMPLER



CVS REMOTE CONTROL CONSOLE



DYNAMOMETER DISPLAY PANEL



ENGINE ANALYZER

Figure 3-8. OLSON LABORATORIES EMISSION TEST EQUIPMENT

a. Volumetric Measurements (7-Mode and Key-Mode Testing)

- Clayton Variable Inertia Dynamometer with 250-pound increment inertia loading weights and road-loading characteristics.
- Olson-Horiba AIA-Non-Dispersive Infra-Red (NDIR) Analyzers in OLI (EPA qualified) sampling system.

  The analyzers have the following full-scale ranges:

Carbon monoxide	0 - 10%
Carbon dioxide	0 - 15%
Low hydrocarbon	0 - 1,000 ppm
High hydrocarbon	0 - 1%
Nitric oxide	0 - 1,000/4,000 ppm

- OLI/Process Computer Systems (Hewlett-Packard) Special Digital Computer (EPA qualified) with programs to provide data readouts on both volumetric and mass equivalent bases and on a mode-by-mode basis.
- Model 4,000 Autoscan Engine Analyzer.
- OLI programmed Driver's Aid.
- Calibration gases analyzed to ±2 percent.
- Gas racks and other special equipment.

b. Mass Measurements (1972 Federal Test Procedure)

- Clayton Variable Inertia Dynamometer with 250-pound increment inertia loading weights and road-loading characteristics.
- Olson-Horiba and Thermo-Electron analyzers in an Olson-Horiba Sampling System consisting of:

  - Olson-Horiba AIA NDIR Analyzers

For CO	0 - 0.3/3/10%

  - Olson-Horiba FID-2

Flame ionization analyzer for total hydrocarbons	0 - 100 ppm carbon
	0 - 500 ppm carbon
	0 - 1,000 ppm carbon
	0 - 10,000 ppm carbon
	0 - 50,000 ppm carbon

  - Thermo Electron chemiluminescense analyzer for NOx.

- OLI Drivers' Aid for EPA cycle.
- OLI Constant Volume Sampler designed to specifically meet the requirements stipulated in the Federal Register (Volume 36, No. 128, dated 2 July 1971).
- Calibration gases analyzed to ±2% and other special equipment.

All facilities and instrumentation used on the retrofit emission program adhere to strict standards designed to assure accurate test results. Daily and weekly checks ascertain that all instrumentation are calibrated and performing to specification. In addition, periodic but unannounced on-site inspections and evaluations were made both by EPA and Olson Quality Control personnel to verify Olson Laboratories' testing accuracy.

SECTION 4
SYSTEM DESCRIPTIONS

Sufficient data were obtained through the data survey and test program to prepare system descriptions for 65 retrofit devices. These descriptions were prepared in accordance with the information requirements of Contract Exhibit A, Section III-C. Each description was based on a system analysis and evaluation covering the technical and cost characteristics shown in Table 4-1. This analysis, together with emission and performance data obtained from the test program, provided the quantitative inputs to the performance parameter index analysis described in Section 5.

4.1 SYSTEM DESCRIPTION OUTLINE

Each system description was prepared in accordance with the following outline:

a. Physical Characteristics: Description and illustration of the device in terms of physical configuration, size, weight, and physical makeup, including photographs when hardware was available.

b. Functional Characteristics: Description of how the device operates.

c. Performance Characteristics: Tabulation and discussion of the overall performance capabilities of the device in accordance with the information requirements of Table 4-2.

d. Driveability: Discussion of vehicle driveability performance with the device installed, with analysis of device characteristics causing adverse performance.

e. Reliability: Discussion and analysis of reliability in terms of mean miles between failure.

f. Maintainability: Discussion and analysis of maintainability in terms of mean time to repair and mean time to maintain. Also a description of the kind of maintenance and inspection required and frequency, with details of inspection rejection criteria.

g. Safety: Safety analysis of failure modes and effects and hazardous conditions.

h. Installation Description and Costs: Description of procedural steps to install the device on a typical vehicle, including labor skills, tools, and manhours. Costs were based on the initial retail value of the device plus the installation costs.

Table 4-1. RETROFIT METHOD PERFORMANCE PARAMETER EVALUATION MATRIX

RETROFIT EVALUATION MATRIX						
DESIGN OBJECTIVES			PERFORMANCE STANDARDS		TEST REQUIREMENTS	
RETROFIT SYSTEM EFFECTIVENESS	DEVICE EMISSION REDUCTION PERFORMANCE	EMISSION REDUCTION	HC HYDROCARBON REDUCTION	GM/MI PPM	SEVEN MODE TEST COLD CYCLE HOT CYCLE 1972 FEDERAL TEST PROCEDURE SOURCE ALTERNATE TEST	UNEQUIPPED VEHICLE BASELINE
			CO CARBON MONOXIDE REDUCTION	GM/MI %		SYSTEM EQUIPPED VEHICLE ZERO MILE TEST
			NO NITROGEN OXIDE REDUCTION	GM/MI PPM		DRIVEABILITY TESTING
			PARTICULATE EMISSION REDUCTION	GM/MI		EXTENDED MILEAGE DURABILITY TESTING
	VEHICLE PERFORMANCE	SAFETY	NO HAZARDOUS FAILURE MODES		SYSTEM FAILURE MODE FAILURE EFFECT ANALYSIS	
			NO HAZARDOUS OPERATING CHARACTERISTICS		FAULT HAZARD STUDY COMPONENT TESTS	
			NO NOXIOUS OR TOXIC FUMES		ODOR PANEL TEST ANALYTICAL MEASUREMENTS	
		ADAPTABILITY	UNCONTROLLED MOTOR VEHICLES UNDER 6,000 LBS GROSS VEHICLE WEIGHT		FIT AND FUNCTION INSTALLATION VERIFICATION	
		VEHICLE DRIVE & OPERATING QUALITY	NO HARD STARTING - ROUGH IDLE NO STUMBLE - STALL - SURGE NO HESITATION - STRETCHINESS (NO ACCEL/DECEL DEGRADATION) NO DETONATION - BACKFIRE		CITY DRIVING SUBURBAN DRIVING ENVIRONMENTAL STRESS (MOUNTAINS/DESERT)	DRIVEABILITY ROAD TEST
		AVAILABILITY	MEAN MILES TO SYSTEM FAILURE MEAN TIME TO REPAIR/MAINTAIN		RELIABILITY AND MAINTAINABILITY ANALYSIS	
RETROFIT SYSTEM COSTS		INITIAL COSTS	REASONABLE COST STRUCTURE IN TERMS OF AVAILABLE MARKET		MANUFACTURING COST DISTRIBUTION COST DEVICE RETAIL AND INSTALLATION COST	
			MAXIMUM COST CRITERIA			
		RECURRING COSTS	DOES NOT DEGRADE OPERATING ECONOMY		OPERATING ECONOMY TESTING - CONSUMABLES	
			NO SIGNIFICANT INCREASE IN VEHICLE MAINTENANCE COSTS		DURABILITY TESTING VEHICLE FAILURE ANALYSIS	
			EMISSION SYSTEM MAINTENANCE AND SERVICE COST CRITERIA		SERVICE LIFE AND REPAIR COST EVALUATION	

Table 4-2. DEVICE NO.____ PERFORMANCE CHARACTERISTICS

EMISSION REDUCTION CHARACTERISTICS		
EVALUATION PARAMETER	PARAMETER CRITERIA	PERFORMANCE RATING/COMMENT
HC	350 ppm(1) or 4.5 gm/mi.(2)	**Emission standards using the 1970 Federal Test Procedure (7 cycles with 7 modes per cycle). Values should be different when applying 1972 Federal Test Procedure.**
CO	2% or 47.6 gm/mi.	
NOx	800 ppm or 3.0 gm/mi.	
GENERAL PERFORMANCE CHARACTERISTICS (3)		
Driveability	AMA Cold Start & Warm Vehicle Driveability	
Safety	No Human or Vehicle Hazards	
Reliability	50,000 mi.	
Mean Miles Before Maintenance (MMBM)	12,000 mi.	
Maintenance Cost Per 12,000 mi.	$15	
Fuel Type	Manufacturer's Specifications	
Fuel Consumption	As Measured	

NOTES:

(1) Parts per million (ppm) are based on California standards for retrofit method accreditation as set forth in the California Health and Safety Code, Chapter 4, Article 5 (refer to Appendix E).

(2) Grams per mile (gm/mi) were calculated by the procedure set forth in the 1970 Federal Test Procedure.

(3) Criteria for reliability, MMBM, and maintenance cost/year based on California standards (same reference as Note 1).

i. Feasibility Summary: Summary of the device's overall feasibility for retrofit application based on its emission reduction performance, driveability, reliability, maintainability, cost, development status, and vehicle adaptability.

4.2 APPROACH TO PERFORMANCE PARAMETER ANALYSES

The system descriptions were prepared by a team of engineers representing the key technologies of retrofit device design. The team consisted of a system analyst, a mechanical systems engineer, an electrical systems engineer, and a reliability/maintainability analyst.

4.2.1 Emissions Reduction

Emissions data were taken first from the test program if tests were performed on the device, and if not, then from the developer's data. If the latter did not include emissions data, this performance parameter was recorded as "not available."

4.2.2 Reliability

Each kit was evaluated against the assumed baseline requirement of 50,000 mean-miles-before-total-failure (MMBTF). As noted in Table 5-1, this criterion is the legal standard established for retrofit devices in California.

The method of evaluation considered the functions to be performed by the device and the components and structure required for performance. In lieu of failure rate data availability, components were evaluated by comparison with analogous types of components having known failure rates.

Electronic component systems containing as many as 60 to 70 components can be produced with MTBF's (mean-time-between-failures) exceeding 30,000 hours. For a system incorporating such components, this would result in a mean-miles-before-partial-failure (MMBPF) capability in excess of 1,000,000 miles (assuming an average speed of 35 miles per hour). Such a device could be a transistorized ignition system or capacitor discharge ignition system. Obviously, calculation of such failure rates would have been academic. More pertinent was the identification of critical components requiring reliability analysis before their selection for system use.

Electromechanical devices such as solenoids, and others such as mechanically and thermally controlled valves, were evaluated in a different manner. These fell into two categories:

a. Standard components available for procurement and in general automotive or equivalent environmental use.

b. Components fabricated specifically for the particular retrofit kit.

Comparisons with generically similar components determined whether or not a component in the first category could meet a minimum life requirement of 50,000 miles and what its MMBTF could be rated nominally. In the event of doubt that the component could meet the requirement, it was identified and noted as a repair or replacement item for scheduled maintenance in order not to jeopardize the 50,000 MMBTF requirement.

Components in the second category, those peculiar to the system, were evaluated by means of available developer data, physical hardware examination, and items performing similar functions in similar environments. Identification of items for maintenance action was accomplished as for items in the first category, if the 50,000 MMBTF requirement could not be met.

The following values were estimated for each major component of a retrofit device.

a. Failure Interval: Quantified by the parameter mean-miles-before-total-failure (MMBTF) or mean-miles-before-partial-failure (MMBPF). In almost all cases, these parameters were estimated to exceed 50,000 miles based on knowledge of comparable automotive components. In any case, the MMBTF used was the total service life which the device was expected to achieve; whereas, the MMBPF was the expected number of miles a device would be in operating condition (available to perform its function), based on the mean of all partial failures it might have during its service life.

b. Repair Parts Cost: This cost was estimated based on the cost of a comparable automotive part and in context with overall retail costs submitted by the developer.

c. Corrective Maintenance Labor: Labor for corrective maintenance associated with each component failure, quantified by the mean time required to repair (MTTR) partial failure times the labor rate.

As each retrofit device was individually evaluated for component failures, a master chart of corrective maintenance actions and mean mileages was prepared as shown in Volume I, Table 4-7. In this table, corrective maintenance actions associated with a component failure were reduced to a list of 18 typical repair actions. For each device, the average component material costs, labor hours, and MMBPF associated with repair actions were listed in the appropriate box within the matrix. These data were then used as inputs to the cost index of the performance analysis.

4.2.3 Maintainability

The method for estimating retrofit maintainability requirements closely paralleled the method used in making reliability estimates. First, each retrofit device was examined for preventive maintenance requirements by considering it comparable to a conventional automotive counterpart. For each retrofit device examined, the following information was determined and listed:

a. Preventive maintenance action description.

b. Maintenance interval, quantified by the mean-miles-before-maintenance (MMBM) interval.

c. Labor associated with the preventive maintenance action, listed as mean-time-to-maintain (MTTM).

d. Material and part costs related to the maintenance action.

After each device was individually analyzed for probable maintenance actions and associated intervals and costs, a composite table was constructed, in which the list of maintenance actions was reduced to 18 typical actions applicable to the maintenance required for individual devices. Maintenance interval (MMBM) and associated labor (MTTM) were then entered in the resulting matrix, as shown in Volume I. Total parts cost and labor for all preventive maintenance actions were also tabulated and averaged. The MMBM was calculated as the average of the miles before maintenance action. The MTTM was calculated as the average of the time required to accomplish each maintenance action. The average cost of maintenance parts, MMBM, and MTTM were used as inputs to the performance analysis.

4.2.4 Driveability and Safety

Driveability is a matter that is highly dependent on the driver and the vehicle. Therefore, driveability test results were discussed with the personnel conducting the tests as part of the evaluation process.

Under the driveability test procedures of the American Automobile Association, the terms used to describe the driveability characteristics to be evaluated include rough idle, stall at idle, stall, backfire, detonation, surge, stretchiness, hesitation, cranking time, and number of attempts to start. Observations were made to detect these conditions under a wide variety of circumstances, including mountain, desert, and city driving. Backfire and stall under both hot and cold conditions were identified as critical elements, whereas the other elements were identified in the category of general driveability.

Analysis of the devices on the merits of safety was based on such factors as exhaust gas leakage, leakage of raw fuel, introduction of raw fuel to a source of ignition which could result in a fire hazard, catastrophic engine failure or loss of power which could occur under hazardous driving conditions, and excessive temperatures.

Potential hazards were identified and noted for both normal system operation and in the event of system failure. The analyses were performed by assuming failure of each component, some individually and some in conjunction with others, and determining the impact on safety. Consideration was given to specific failure modes and fatigue resulting from device operational modes, such as cyclic loading, and from engine vibration or heat. These failures were incorporated in the reliability analysis.

4.2.5 Installation Procedures

The initial step in determining the installation procedure and cost for the retrofit devices was to gather all the installation data available and put it in a standard format. Table 4-3 illustrates the worksheet used for this purpose.

Table 4-3. INSTALLATION PROCEDURES: DEVICE NO. ___

INSTALLATION AND ADJUSTMENTS PROCEDURE	TOOLS, EQUIPMENT, AND FACILITIES	TIME REQUIRED	LABOR SKILL LEVEL

The questions sent out to the developer's specifically requested installation procedures and cost information. Much of the material provided included detailed installation procedures on a step by step basis. These were used as provided. Many instances occurred wherein no procedures were described but installation sketches were available. Step by step procedures were then developed from the sketches. In instances where the device had been tested at the Anaheim facility, the actual installation procedure for this installation was used.

A list of required material was made up based on the installation procedures. The tools, equipment, and facilities required to carry out the installation, test, and adjustment procedures were identified from the same installation procedures.

The estimated number of hours for installation was taken from the data provided by retrofit source. Installation hours were verified by estimating hours for each step of the installation procedure. The estimated retail cost of material was taken from the source material. When this retail cost was considered unrealistic, a cost estimate based on historical cost data was developed.

4.2.6 Initial and Recurring Costs

4.2.6.1 Initial Costs

The number of hours required for installation, test, and adjustment was estimated from the detailed installation procedure, and recorded in the form shown by Table 4-4.

Table 4-4. INSTALLATION COST: DEVICE NO. _______

ITEM		DESCRIPTION	HOURS	COST
Material	(1) Device			
	(2) Miscellaneous			
Labor	(1) Installation			
	(2) Test and Adjust			
Total				

The hours estimated were compared to the estimate provided by the developer to determine whether there was any significant difference between the two. The labor cost was determined by multiplying the hourly rate of $12.50 by the number of hours. The estimated retail cost of the material was taken from the developer's source material unless this retail cost was considered unrealistic. In the latter case, a cost estimate based on historical cost data for similar items was used.

Based on the data derived in this manner, a summary of the installation procedure, cost, and special requirements was prepared for each device.

4.2.6.2 Recurring Costs

Recurring costs are defined and evaluated mathematically in Volume III. A simple definition of recurring costs are the total costs associated with a retrofit device other than initial costs. These recurring costs are those associated with retrofit repair, maintenance, and increased or decreased fuel consumption. The recurring costs are expressed in terms of dollars-per-mile driven and consist of a summation of the following factors:

a. Repair Costs per Mile Driven: This cost term consists of material and labor costs associated with the repair of failed retrofit components. Mathematically it is evaluated from the 1) mean-time-to-repair (MTTR), 2) mean-miles-before-partial-failure (MMBPF), 3) average costs of repair parts (C_{RP}), and 4) repair labor rates (L_C dollars per hour).

b. Preventive Maintenance Costs per Mile Driven: The cost term consists of material and labor costs associated with preventive maintenance conducted as a result of retrofit installation. Mathematically it is evaluated from 1) the mean-miles-before (preventive) maintenance (MMBM), 2) the mean-time-to-maintain, 3) the cost of maintenance parts (C_{MP}) and 4) the maintenance labor rate (L_C dollars per hours).

c. Fuel Penalty (or Benefit) Costs: This cost reflects increased (or decreased) fuel costs resulting from retrofit installation. This cost, in dollars per mile driven, is computed based on 1) fuel consumption with the device installed (gallons per mile), 2) fuel consumption without the device installed, and 3) fuel cost (dollars per gallon).

Calculation of total recurring costs is relatively straightforward once the factors MMBPF, MTTR, MMBM, MTTM, repair parts cost (C_{RP}), and maintenance parts costs (C_{MP}) have been evaluated for each device. The method by which these factors were calculated is discussed in Volume III.

When recurring costs were computed it was decided that the effect of increased fuel consumption would not be included in recurring costs for those devices which were not tested in this program. This decision was made because most developers did not submit fuel consumption data, and many of those who did reported questionable improvements in economy. However, fuel consumption was measured for the 11 devices tested in the laboratory and was included in their recurring cost calculations.

SECTION 5
PERFORMANCE ANALYSIS

The system analyses of Section 4 and the supplementary tests of Section 3 provided the data necessary to evaluate the effectiveness and costs of the respective retrofit methods and devices. To organize the many effectiveness and cost variables for orderly evaluation, an evaluation methodology was developed in the form of a mathematical model. This model was implemented on IBM Model 360/65 and 370/165 computers in H-level FORTRAN.(1)

5.1 EVALUATION METHODOLOGY EQUATIONS

A detailed discussion of these equations is presented in Volume III, Section 3, because of the pertinency of the equations to the evaluations presented in that volume. The concept of these equations was to organize the effectiveness and cost variables or parameters into a logical and orderly structure, by which the effectiveness and costs of devices could be methodically derived. The equations also provided a means of demonstrating that all significant variables were identified and interrelated according to their interdependencies.

This concept was implemented by defining the basic constraints of the analysis. These were.

a. The effectiveness of the retrofit device in reducing vehicle emissions.

b. The impact of the retrofit device on the performance of the vehicle.

c. The cost of the device.

Groups a. and b. separate the overall effectiveness constraint into two opposing constraints: 1) those which benefit vehicle operation by reducing emissions, and 2) those which detract from vehicle operation by causing loss of vehicle performance. The benefits must offset the detractions in order for the retrofit device to be justified for use. Also, the benefits must be obtainable at an acceptable cost. The mathematical interaction of these constraints shows whether or not the emission reduction benefit offsets any vehicle performance loss enough to justify the cost of obtaining the benefit.

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(1) Use of H-level FORTRAN is explained in Document File No. S360-25, Form C28-6817-0, IBM Systems Reference Library, IBM System/360 Operating System, FORTRAN IV (G and H) Programmer's Guide, First Edition, November 1968, International Business Machines Corporation.

After defining these basic constraint groups, which together establish the boundaries of the problem to be analyzed, the individual effectiveness and cost parameters were allocated to each group according to their particular constraint characteristics. This allocation provided the following constraint groups:

a. Retrofit device emission reduction effectiveness groups:
    1. HC percent difference with and without the device installed on the vehicle.
    2. CO percent difference with and without the device installed on the vehicle.
    3. NOx percent difference with and without the device installed on the vehicle.
    4. HC levels versus Government standard.
    5. CO levels versus Government standard.
    6. NOx levels versus Government standard.

b. Retrofit device impact on vehicle performance effectiveness group:
    1. Impact of the device on safety of vehicle operations.
    2. Impact of the device on critical driving modes.
    3. Impact of the device on general driving comfort.

c. Retrofit device cost in terms of:
    1. Initial costs:
        (a) How much the retail cost of the device is.
        (b) How much it costs to install the device.
    2. Recurring cost:
        (a) How many miles the device can be used before it has to be replaced (the MMBTF of the device).
        (b) How many miles it can be used before it has to be repaired (MMBPF) or maintained (MMBM - the operability of the device in total miles before maintenance).
        (c) How many hours it takes to maintain or repair the device in terms of the mean-time-to-maintain (MTTM) and mean-time-to repair (MTTR), plus the cost of maintenance and repair parts.
        (d) How much more the vehicle costs to operate with the device installed, in terms of fuel consumption.

5.1.1 Performance Criteria Index Evaluation

Each of these performance parameters constitutes a separate performance factor. These factors may be evaluated against their respective performance criteria and, if they meet the criteria, be given a value of 1, signifying acceptable with respect to the criteria/or a value of 0, signifying nonacceptance. When the parameters are multiplied, the product will equal 0 if any of the parameters are 0. This shows that the device does not meet all of the criteria. If a device does meet all criteria, the product of the performance parameters will equal one.

The factors and criteria used in this evaluation are shown in Table 5-1.

5.1.2 Performance Index Evaluation

These performance parameters may also be evaluated in terms of the overall performance index of the device, by:

$$\text{Performance Index} = \frac{C_1\ (\text{Emission Index}) - C_2\ (\text{Driveability Index}) - C_3\ (\text{Cost Index})}{(C_1 + C_2 + C_3)}$$

where C_1, C_2, and C_3 are weighting factors that may be used to vary the relative importance of the three constraint groups. For example, emission reduction may be desirable at a sacrifice of driveability or cost; or the percentage reduction of emission provided may not be as significant as low cost. Whichever the case, appropriate weighting factors may be applied to increase or decrease the relative importance of the basic parameter groups.

5.1.3 Cost Effectiveness Index Evaluation

The third way in which the retrofit device parameters may be evaluated is in terms of the device's effectiveness and cost. For this evaluation, the driveability constraint is removed, so as to give emphasis to the emission reduction performance of the device in terms of the percent reduction per dollar of cost per mile of vehicle operation. This is called the cost effectiveness index and is shown by:

$$\text{Cost Effectiveness Index} = \frac{\text{Emission Index}}{\text{Cost Index}}$$

5.2 METHODOLOGY IMPLEMENTATION

The requirement for iterative variation of the performance index analysis equation parameters required that a computer be used. A program was written for the IBM System 360/65 and 370/165 High Speed Digital Data Processor in H-level FORTRAN. The program read the equation parameter values into the computer in punched card form and performed an iteration for each car and device tested. The output was the performance index rating and the subindex values.

The program also computed the mass exhaust emission values from the volumetric concentration values for HC, CO, and NOx and provided this as an output. As a necessary byproduct, the humidity correction factor was determined from the wet bulb and dry bulb psychrometic readings and applied to the NOx calculation.

Table 5-1. PERFORMANCE PARAMETERS AND EVALUATION CRITERIA

FACTOR	CRITERIA
1. Emission Index Factors	
a. Emission standards (1)	
HC CO NOx	Less than 350 ppm or 4.5 gm/mi Less than 2.0% or 47.6 gm/mi Less than 800 ppm or 3.0 gm/mi
b. Emission baseline	No increase of any pollutant beyond an allowable experimental error (2)
2. Driveability and Safety Index Factors	
a. Safety	No hazardous conditions
b. Critical driveability	No stall on acceleration No hot idle stall No backfire
c. General driveability	Driveability Index less than 1.0 (refer to para. 3.1.5)
3. Cost and Cost-Related Index Factors	
a. Installation cost (including kit)	Less than $85.00, including labor at $12.50 per hour (3)
b. Recurring cost	Less than $15.00 per year ($0.125 per 100 miles) (4)
c. Reliability	At least 50,000 miles of operation before total failure
d. Maintainability	At least 12,000 miles of operation before periodic maintenance is required
e. Availability	Less than 1 repair hour per 12,000 miles of operation (4)

(1) The volume concentration values are the California used car device accreditation standards as specified in California Health and Safety Code Chapter 4, Article 2, paragraph 39107 (refer to Volume IV, Appendix E). These standards are for the 7-mode cold-start test cycle specified in the 1970 Federal Test Procedure (see pertinent comments and cautions in Volume III, Section 5.1). The grams per mile (gm/mi) correlated with the above standards were calculated for a 4,000-pound vehicle in accordance with the method set forth in the 1970 Federal Test Procedure. If the evaluator intends to use the 1972 Federal CVS Test Procedure, appropriate used car standards must be established for that test procedure.

(2) In this report, an experimental error of +10% was used.

(3) $12.50 per hour based on California repair labor average.

(4) Average miles driven per year assumed to be 12,000 miles.

5.2.1 Information Flow

The flow of information consists of three branches as shown in Figure 5-1.

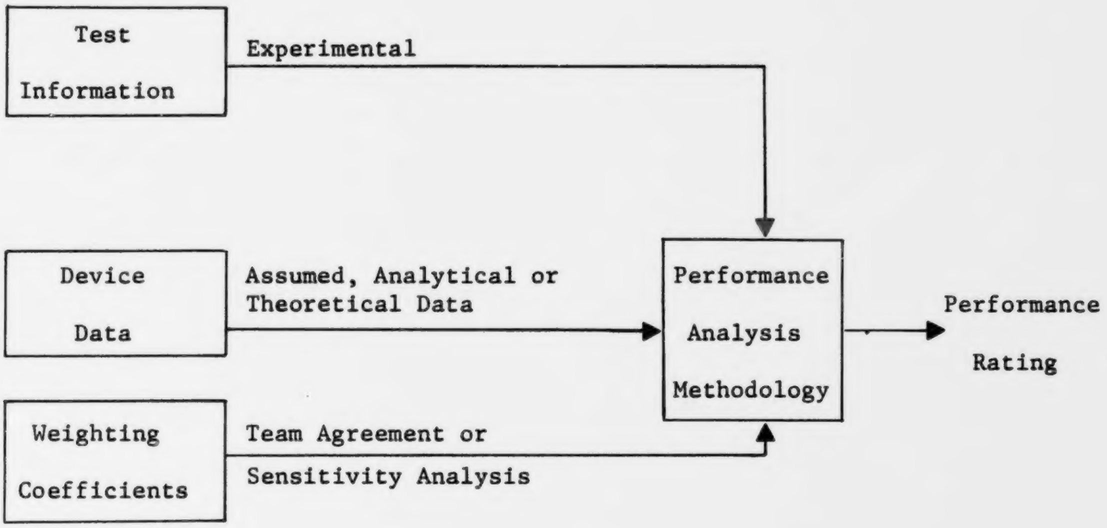

Test Information
Experimental
Device Data
Assumed, Analytical or Theoretical Data
Performance Analysis Methodology
Performance Rating
Weighting Coefficients
Team Agreement or Sensitivity Analysis

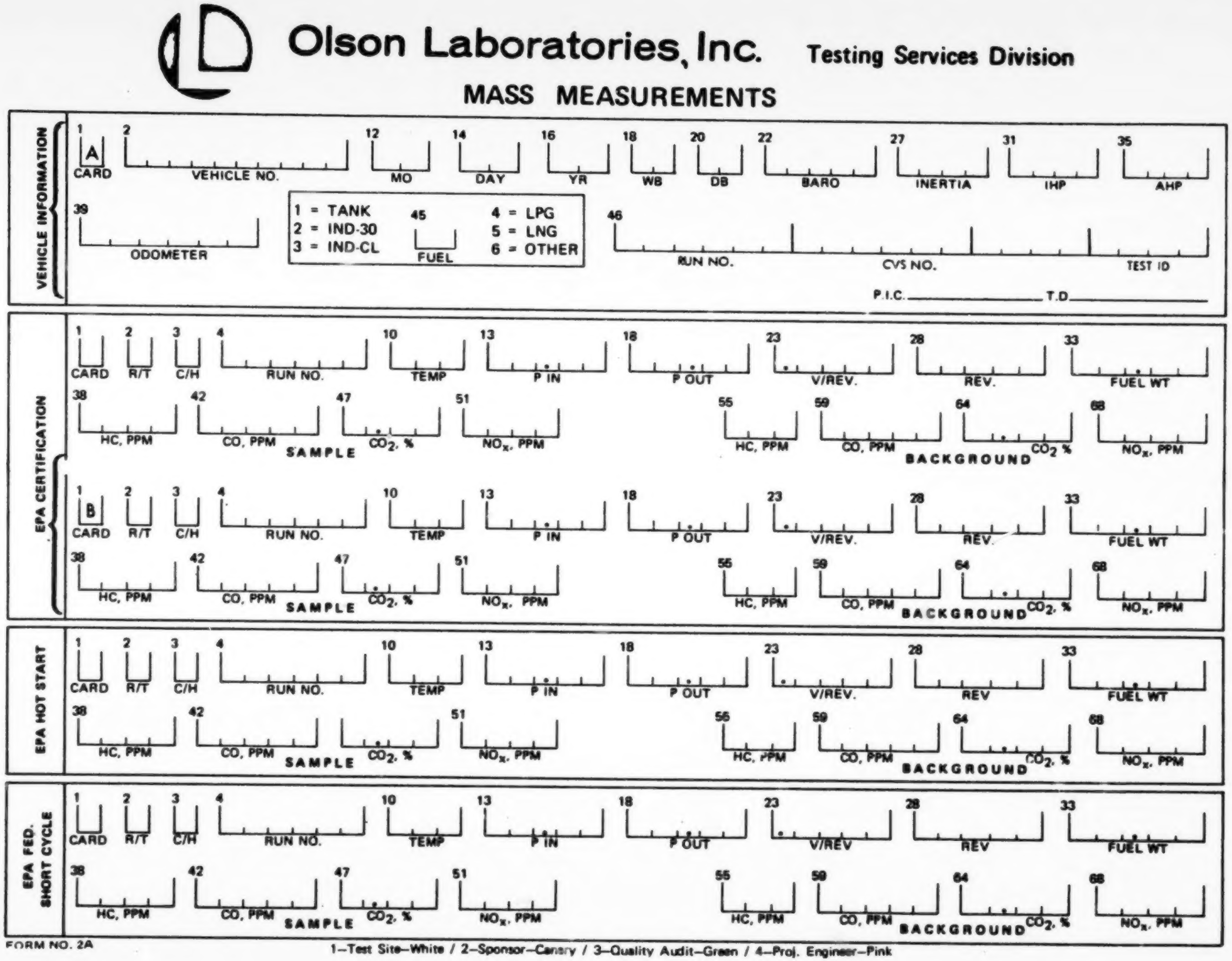
Figure 5-1. RETROFIT INFORMATION FLOW TO COMPUTER

One is related to the vehicle test information that provides reliable quantitative data; the second branch is related to retrofit device data that may be developer test data, engineering assumptions, analytical evaluations, or theoretical estimates; and the third branch is related to estimated weighting coefficients which were established through sensitivity analysis and by agreement among the project team. All data inputs were reviewed for correctness and accuracy.

The test information was recorded on formated test data sheets which were then keypunched for computer input. These formats are shown in Figures 5-2 and 5-3. Information required by the Federal Register, Volume 35, No. 219, November 10, 1970 and subsequent revisions, was included on the emissions data sheet or was constant for the test facility or the test procedure.

The device data were obtained primarily from information supplied by the retrofit device developer, and were considered of a second order of validity to the laboratory evaluations, since they were derived under different test conditions. Also, the validity of tests, analyses and theoretical estimates varies with the level of experience or expertise of the estimator. The stage of development of the device itself varied from the drawing board to proven production model with a consequent increased confidence in the provided data. These data were encoded on standard 80-column forms for keypunch and subsequent computer input as shown in Figure 5-4.

The weighting coefficients were initially chosen based on engineering judgments. These coefficients were then subjected to a sensitivity analysis to determine the parameters sensitive to small changes in value. These sensitive parameters were



Olson Laboratories, Inc. Testing Services Division

MASS MEASUREMENTS

VEHICLE INFORMATION

1 A CARD · 2 VEHICLE NO. · 12 MO · 14 DAY · 16 YR · 18 WB · 20 DB · 22 BARO · 27 INERTIA · 31 IHP · 35 AHP

39 ODOMETER · 45 FUEL · 46 RUN NO. · CVS NO. · TEST ID

1 = TANK
2 = IND-30
3 = IND-CL
4 = LPG
5 = LNG
6 = OTHER

P.I.C. ____________ T.D. ____________

EPA CERTIFICATION

1 CARD · 2 R/T · 3 C/H · 4 RUN NO. · 10 TEMP · 13 P IN · 18 P OUT · 23 V/REV. · 28 REV. · 33 FUEL WT

SAMPLE: 38 HC, PPM · 42 CO, PPM · 47 CO_2, % · 51 NO_x, PPM

BACKGROUND: 55 HC, PPM · 59 CO, PPM · 64 CO_2 % · 68 NO_x, PPM

1 B CARD · 2 R/T · 3 C/H · 4 RUN NO. · 10 TEMP · 13 P IN · 18 P OUT · 23 V/REV. · 28 REV. · 33 FUEL WT

SAMPLE: 38 HC, PPM · 42 CO, PPM · 47 CO_2, % · 51 NO_x, PPM

BACKGROUND: 55 HC, PPM · 59 CO, PPM · 64 CO_2, % · 68 NO_x, PPM

EPA HOT START

1 CARD · 2 R/T · 3 C/H · 4 RUN NO. · 10 TEMP · 13 P IN · 18 P OUT · 23 V/REV. · 28 REV · 33 FUEL WT

SAMPLE: 38 HC, PPM · 42 CO, PPM · CO_2, % · 51 NO_x, PPM

BACKGROUND: 56 HC, PPM · 59 CO, PPM · 64 CO_2, % · 68 NO_x, PPM

EPA FED. SHORT CYCLE

1 CARD · 2 R/T · 3 C/H · 4 RUN NO. · 10 TEMP · 13 P IN · 18 P OUT · 23 V/REV · 28 REV · 33 FUEL WT

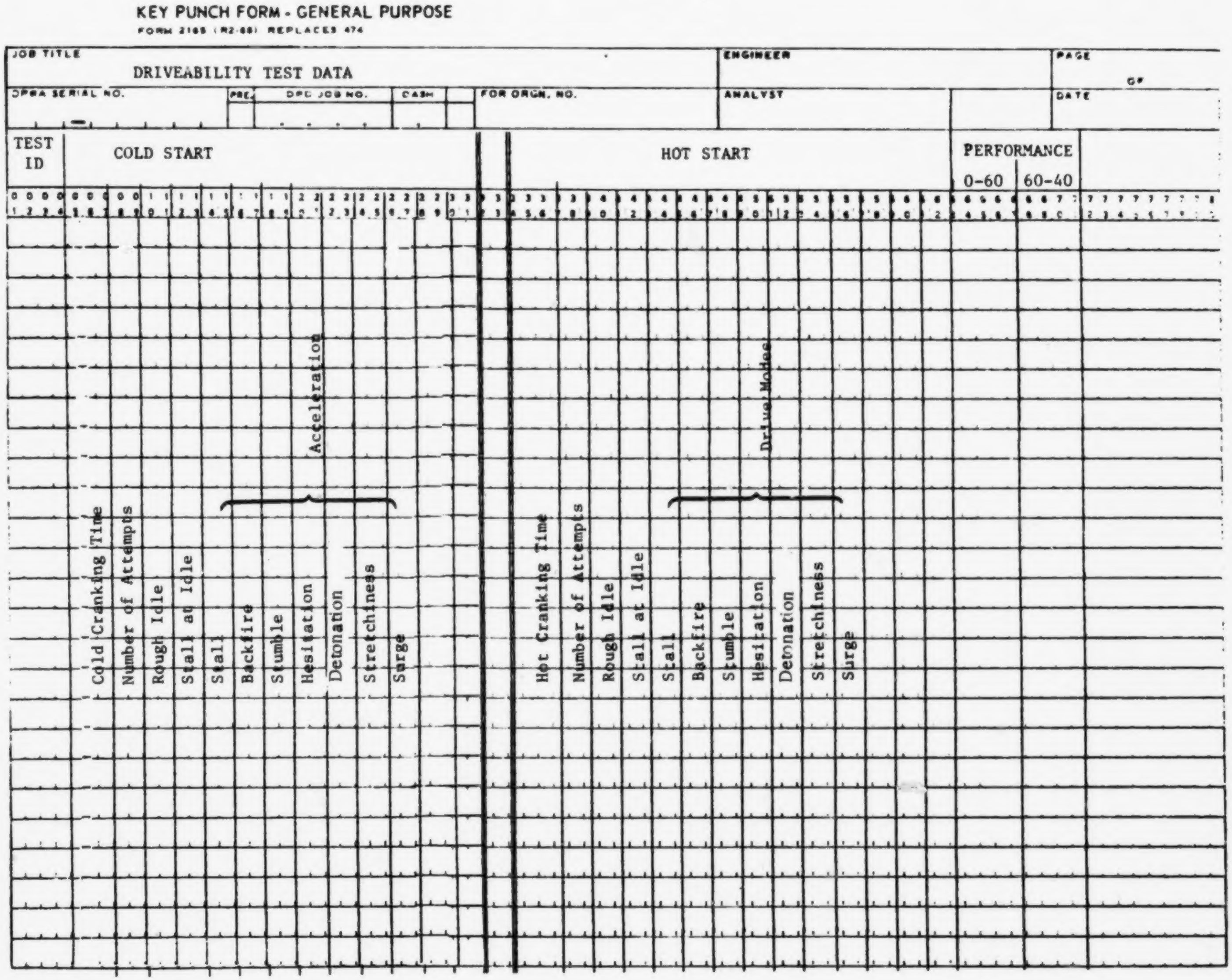
SAMPLE: 38 HC, PPM · 42 CO, PPM · 47 CO_2, % · 51 NO_x, PPM

BACKGROUND: 55 HC, PPM · 59 CO, PPM · 64 CO_2, % · 68 NO_x, PPM

FORM NO. 2A

1—Test Site—White / 2—Sponsor—Canary / 3—Quality Audit—Green / 4—Proj. Engineer—Pink

Figure 5-2. EXHAUST EMISSIONS COMPUTER INPUT SHEET



KEY PUNCH FORM - GENERAL PURPOSE
FORM 2165 (R2-68) REPLACES 474

JOB TITLE DRIVEABILITY TEST DATA
ENGINEER
PAGE OF
OPRA SERIAL NO.
PREL
OPC JOB NO.
CASH
FOR ORGN. NO.
ANALYST
DATE

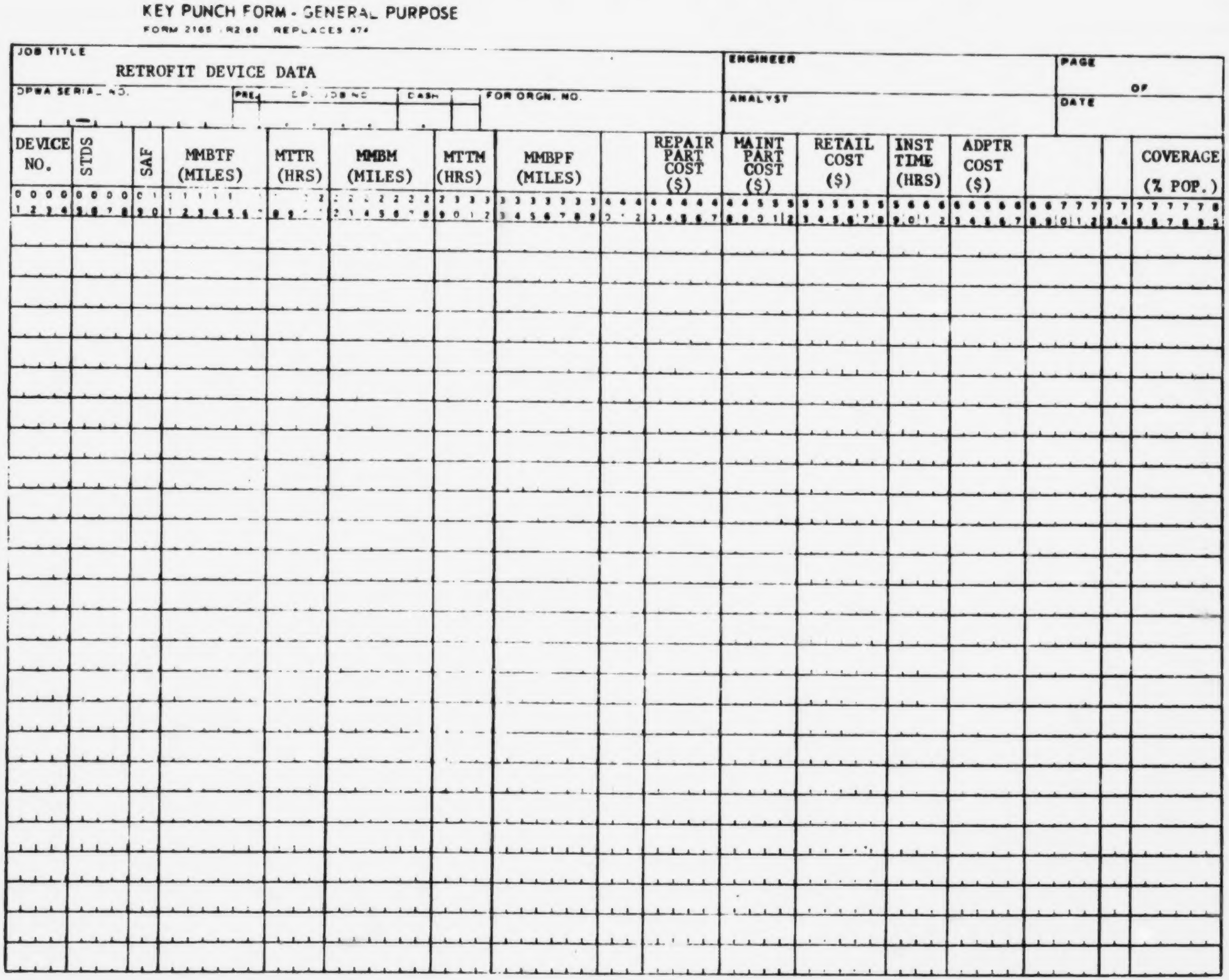
TEST ID

COLD START: Cold Cranking Time; Number of Attempts; Rough Idle; Stall at Idle; Acceleration: Stall, Backfire, Stumble, Hesitation, Detonation, Stretchiness, Surge

HOT START: Hot Cranking Time; Number of Attempts; Rough Idle; Stall at Idle; Drive Modes: Stall, Backfire, Stumble, Hesitation, Detonation, Stretchiness, Surge

PERFORMANCE: 0-60; 60-40

Figure 5-3. DRIVEABILITY TEST DATA INPUT SHEET



KEY PUNCH FORM - GENERAL PURPOSE
FORM 2165 (R2-68) REPLACES 474

JOB TITLE RETROFIT DEVICE DATA
ENGINEER
PAGE OF
DPWA SERIAL NO.
PRE. E.P. JOB NO. DASH
FOR ORGN. NO.
ANALYST
DATE

DEVICE NO.	STDS	SAF	MMBTF (MILES)	MTTR (HRS)	MMBM (MILES)	MTTM (HRS)	MMBPF (MILES)		REPAIR PART COST ($)	MAINT PART COST ($)	RETAIL COST ($)	INST TIME (HRS)	ADPTR COST ($)			COVERAGE (% POP.)

Figure 5-4. RETROFIT DEVICE DATA-INPUT FORM

carefully varied during computer runs and monitored by the technical review committee, which established the values to be finally used. Computer input was provided via the same 80-column form as used for device data.

5.2.2 Computer Program

A first level flow chart of the computer program is shown in Figure 5-5 and a copy of the printed program listing is included as Appendix H. Following input of the data, the constants for the run were printed out so that a record was available should any questions arise regarding the assumptions made for any given run.

The next step in the program utilized the wet and dry bulb psychrometer readings and the barometric pressure to determine the absolute humidity for a given test on a given vehicle. The absolute humidity was then used in the humidity correction factor in the NOx mass emission calculation.

The mass emissions were calculated in accordance with the procedure given in the Federal Register, Volume 36, No. 128, dated 2 July 1971; this procedure adds an NOx calculation to the procedure given in the Federal Register Volume 35, No. 219, dated 10 November 1970. The mass emission values were then printed.

The final function of the program was to calculate the performance rating for the devices evaluated and present the intermediate and final results in various formats to simplify comparisons. Should different coefficient values be desired, the performance ratings were calculated and the result of the new iteration presented.

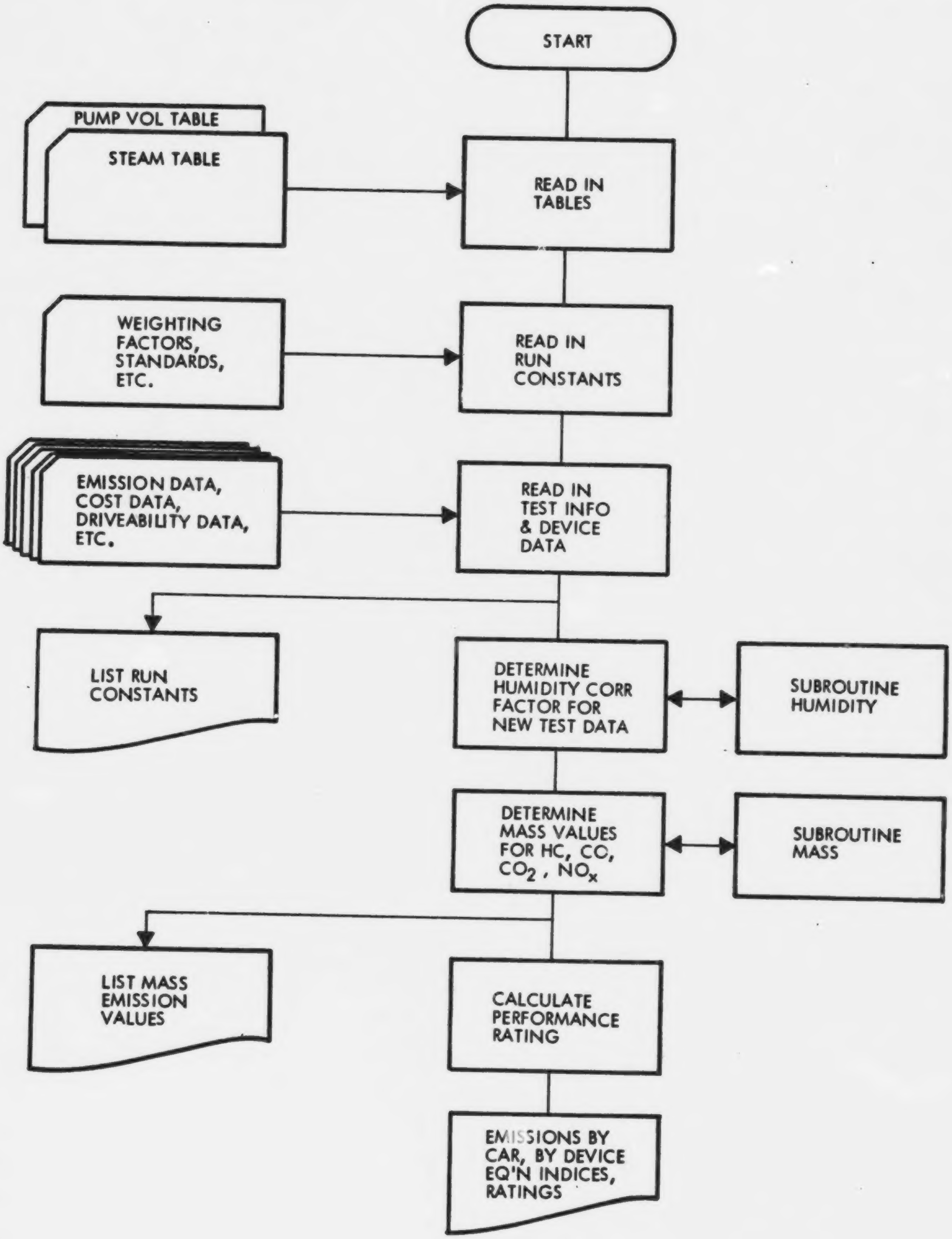

START
PUMP VOL TABLE
STEAM TABLE
READ IN TABLES
WEIGHTING FACTORS, STANDARDS, ETC.
READ IN RUN CONSTANTS
EMISSION DATA, COST DATA, DRIVEABILITY DATA, ETC.
READ IN TEST INFO & DEVICE DATA
LIST RUN CONSTANTS
DETERMINE HUMIDITY CORR FACTOR FOR NEW TEST DATA
SUBROUTINE HUMIDITY
DETERMINE MASS VALUES FOR HC, CO, CO2, NOx
SUBROUTINE MASS
LIST MASS EMISSION VALUES
CALCULATE PERFORMANCE RATING
EMISSIONS BY CAR, BY DEVICE EQ'N INDICES, RATINGS

Figure 5-5. COMPUTER PROGRAM TOP LEVEL FLOW CHART

APPENDIX A

REQUEST FOR RETROFIT SOURCE IDENTIFICATION

Olson Laboratories, Inc.
500 E. ORANGETHORPE AVENUE, ANAHEIM, CALIF. 92801
TELEPHONE: (714) 871-3920, TELEX: 65-5417

July 21, 1971

Subject: Request for Used Vehicle Retrofit
Emission Control Device Manufacturers

The Environmental Protection Agency has awarded Olson Laboratories a Federal Contract for the "Analysis of Effectiveness and Costs of Retrofit Emission Control Systems for Used Vehicles" (Contract No. 68-04-0038). Olson Laboratories is seeking addresses of all known developers and manufacturers of used vehicle emission control systems.

May we obtain the names and addresses of used vehicle emission control device developers that you may have had contact with in the past? Olson Laboratories will request their participation in this evaluation program as outlined in Enclosure 1.

Thank you for your prompt consideration regarding this request.

Sincerely,

Milton J. Webb

Milton J. Webb
Project Engineer

MJW/jm

Enclosure

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APPENDIX B

LETTER OF INQUIRY TO RETROFIT DEVELOPERS

September 14, 1971

The Environmental Protection Agency (EPA) has awarded OLI a Federal contract for the "Analysis of Effectiveness and Costs of Retrofit Emission Control Systems for Used Vehicles" (No. 68-04-0038). This letter is to introduce all retrofit emission control device developers to the program and to solicit your participation.

The term "retrofit" as used in this program is defined as any device or system that may be added to a car and/or any modification or adjustment, beyond that of regular maintenance, which may be made to reduce vehicle emissions. Specifically excluded from retrofit classifications are:

1. Regular vehicle maintenance
2. Engine tune-up
3. The GM, Ford, and Chrysler used car systems
4. Inspection programs

As you know there are nearly 100 million cars operating in the United States with various degrees of emission control devices. Presently, 68% of the vehicle population is not equipped with exhaust emission control systems. 26% do not have crankcase blowby devices and 91% do not have fuel evaporative emission control systems. In 1976, it is predicted that 26% will still be without exhaust emission control systems unless retrofit programs are implemented.

The United States could possibly realize a 25 to 50 percent reduction in total national emissions of carbon monoxide, hydrocarbons, and oxides of nitrogen from gasoline-powered automobiles and trucks. This reduction could be obtained over the next 15 years if feasible used car retrofit emission control programs are implemented by Federal and State agencies. The states have been requested by the Federal Government through the 1970 Clean Air Act Amendments to consider retrofit used car emission control devices as one of several methods to lower total air pollution levels.

To date, the Federal Government and various State agencies have conducted only screening emission tests for the retrofit device industry. This new project, however, is designed to provide a comprehensive analysis of a feasible retrofit emission control system program. The purpose of this program is to provide the EPA with an analysis of the effectiveness and costs of presently known retrofit methods for reducing emissions from used cars and light duty trucks (less than 6000 lbs. GVW). Specifically, the objectives of this program are:

1. To provide the Federal Government and State Agencies, who are responsible for establishing automotive emission control programs, with as much information as is currently available on retrofit emission control systems for used cars.

2. To guide the selection of future tests or developmental efforts.

Olson Laboratories is requesting your participation in this comprehensive retrofit evaluation program. If your company is interested, participation will require the following action:

1. Submit your letter of intent to participate by September 28, 1971.

2. Submit product brochures and any emission test or other data with your letter of intent to participate. Seven-mode emission data by the Federal or California procedures are desirable. If hardware is available at this time please submit two complete systems for the preliminary evaluation. If devices are not readily available at this time, please advise.

3. Following a preliminary evaluation Olson Laboratories will mail a detailed evaluation survey form for the developer to complete and return.

4. Return the evaluation form to Olson Laboratories, Inc.

This program is being funded by the Environmental Protection Agency, and therefore, no monetary obligation for your participation in this program is required. Participation in this comprehensive evaluation program should be to the developer's advantage.

In cases where secrecy is a requirement, a nondisclosure agreement must be negotiated between Olson Laboratories and the developer. We assure you that only performance information will be reported in the final technical report, and that all design details will remain confidential. Over the past several years of device testing, Olson Laboratories has developed a strong history of nondisclosure credibility within the emission control system industry.

If you decide to participate, we must receive your written response by Sept. 28, 1971. At the completion of the project (approximately Dec. 31, 1971) all data and hardware submitted to Olson Laboratories will be returned to the developer.

We look forward to your favorable response, and if there are any questions or you require further details please contact:

Milton J. Webb
Project Engineer
Olson Laboratories, Inc.
500 E. Orangethorpe Ave.
Anaheim, Calif. 92801
(714) 871-3920

Thank you for your time and consideration regarding your participation in this retrofit emission control evaluation program.

Sincerely,

Howard M. Bunch
Vice President

HMB/jm

APPENDIX C

NEWS RELEASE

BREWER ASSOCIATES
806 Oakwood Blvd.
Dearborn, Michigan 48124
561-0440

News Release...

FOR RELEASE IMMEDIATELY

REF. NO. 5016

For further information contact:
Mr. Howard Bunch
Vice President
Olson Laboratories, Inc.
22805 Michigan Avenue
Dearborn, Michigan 48124
(313) 274-8450

Olson Laboratories Awarded Major EPA Contract for

ANALYSIS OF EFFECTIVENESS AND COSTS OF EMISSION CONTROL SYSTEMS FOR USED VEHICLES

Olson Laboratories, Inc., of Dearborn, Michigan, has been awarded a Federal contract from the Environmental Protection Agency (EPA), for the "Analysis of Effectiveness and Costs of Retrofit Emission Control Systems for Used Vehicles".

The need for this program is based on the fact that very few of this country's 100 million light-duty vehicles are equipped with all currently available emission control devices. At present, 91% do not have fuel evaporative emission controls, 68% have no exhaust emission control, and 26% do not have crankcase blowby devices.

If practical and effective emission control equipment can be installed on used vehicles, the U.S. could possibly realize a 25% to 50% reduction in total emission of carbon monoxide, hydrocarbons, and oxides of nitrogen from gasoline-powered automobiles and trucks. This reduction could be obtained over the next 15 years if feasible used-car emission control programs could be implemented by Federal and State agencies.

The test program will be conducted in Detroit and Los Angeles, and cost effectiveness evaluation will be conducted at the Northrup-Olson facility in Anaheim, California. The program began on July 1st, and will be completed by the end of 1971.

The term "retrofit" in this program is defined as any emission control device or system that may be added to a car, or any modification and/or adjustment which may be made to a car to reduce emissions. Specifically excluded from this study are:

1. Regular Vehicle Maintenance
2. Engine Tune-up
3. The General Motors, Ford, and Chrysler used car systems
4. Inspection Programs

Prior to the start of this new project, the Federal Government and various State agencies have conducted only screening emission tests for the retrofit device industry. This new Olson Laboratories test program for EPA is designed to provide a comprehensive analysis which may be used as the basis of a feasible retrofit emission control system program for used vehicles.

Specifically, the objectives of this program are:

1. To determine what retrofit methods for used cars appear feasible at this time, and to investigate their relative emissions reduction effectiveness, installation and operating cost penalties, their eventual effects on fuel type requirements, vehicle driveability, and safety.

2. To provide the Federal Government and State agencies, who are responsible for establishing automotive emission control programs, with as much information as is currently available on retrofit emission control system for used cars.
3. To guide the selection of future tests and product development efforts.

As part of this program, Olson Laboratories will work closely with manufacturers and developers of retrofit devices and systems. The program will include an objective analysis of all devices and systems in terms of emission reduction, safety, driveability, adaptability, and availability. Cost data will also be developed so that a comparative analysis can be made between available systems.

Olson Laboratories has already contacted all or most known manufacturers of retrofit emission controls. Because the program is being funded by EPA, and because valuable information and data will be made available from the study, Olson Laboratories expects excellent cooperation from the manufacturers involved.

Any emission control device manufacturer who has not been contacted by Olson Laboratories is invited to contact the company in either Dearborn, Michigan, or Anaheim, California.

Typical of the retrofits which will be considered in this study are:

1. Devices for crankcase emissions
2. Devices for evaporative emissions
3. Thermal reactors for exhaust emissions

4. Catalytic reactors for exhaust emissions
5. Special calibrations, adjustments, or spark timings
6. Induction system changes, carburétor accessories, etc.
7. Exhaust gas recirculation
8. Combinations of the above methods

Even though a potential retrofit system may not be capable of meeting current or proposed emission standards, it may still be considered for testing in this program.

---000---

Aug 30 10 44 AM '71

OLSON LAB
DEARBORN

brewer associates inc. ba advertising

Dear

Several weeks ago we sent you a news release regarding Olson Laboratories' new contract from the Environmental Protection Agency. The testing and evaluation contract will "Analyze the Effectiveness and Costs of Emission Control Systems for Used Vehicles".

This project could result in a program which would reduce total automotive emissions much more quickly. If a suitable means for controlling emissions from used cars is not developed, the U.S. will have to wait for the gradual emissions reduction which will occur as older cars are retired.

To be completely successful, this project should include testing and evaluation of all possible means for controlling emission. That is the primary purpose of this news release. It is designed to supplement Olson Laboratories' own efforts to contact all potential manufacturers of this kind of equipment.

Have you published a version of this news release? If you have, please let us know which issue and, if possible, please send us a tearsheet. If you have not yet run the release we would appreciate your giving it additional consideration.

Thank you for your cooperation.

Cordially,

BREWER ASSOCIATES, INC.

Gordon S. Garrett

GSG/kl

806 OAKWOOD BLVD • DEARBORN, MICHIGAN 48124 • PHONE 313 561 0440

The following publications will be receiving the letter and news release:

- Pollution Engineering
- Pollution Equipment News
- Autoproducts
- Automotive Engineering (formerly SAE Journal)
- Automotive News
- Automotive Industries
- Machine Design
- Design News
- Product Engineering
- Detroit Free Press
- Detroit News
- Los Angeles Times
- New York Times
- Chicago Tribune
- Cleveland Plain Dealer
- Wall Street Journal
- Business Week
- Houston Post
- Atlanta Constitution
- Washington Post
- Philadelphia Inquirer
- Boston Globe
- Denver Post
- San Francisco Chronicle
- Industry Week

APPENDIX D

RETROFIT DATA QUESTIONNAIRE AND TRANSMITTAL LETTER

Olson Laboratories, Inc.

500 E. ORANGETHORPE AVENUE, ANAHEIM, CALIF. 92801
TELEPHONE: (714) 871-3920, TELEX: 65-5417

Thank you for your interest in the Environmental Protection Agency's (EPA) "Retrofit" device evaluation program. This letter outlines the program outputs and requests more specific input test data for the evaluation process of your retrofit control system.

The 1970 Clean Air Act Amendment requires that the States consider retrofit used vehicle emission control devices as one of several possible methods of lowering total air pollution levels. EPA will provide a criteria document for use by the States in selecting methods to reduce emission levels. Part of this document includes the used car retrofit approach.

The program objectives are to provide a comprehensive analysis of the effectiveness and costs of presently known retrofit systems, and to evaluate the feasibility of the particular methods with regard to installation on the current used vehicle population. Olson Laboratories, Inc., (OLI) will conduct the effectiveness and cost analyses of candidate retrofit systems on the basis of the data submitted to OLI.

The first phase of the evaluation process requires obtaining specific data from you, the retrofit developer. It is recognized that systems in the prototype stage of development may not have been subjected to complete evaluations, and that some of the requested data may not be available from you at this time. However, since the time constraints of this program are limited, we encourage you to provide as much of the requested data as possible.

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An information outline and a retrofit glossary, including instructions, are provided to assist you in presenting the specific information with regard to your retrofit system, and to assist OLI in the evaluation (Enclosures 1 and 2). Please fill in as much of the information as possible on Enclosure 1 and return it to OLI within 2 weeks. In cases where the requested data are not available, write "none," and indicate when (or if) it will be available. Upon receipt of the information outline, a member of the Olson engineering staff will contact you, if necessary, to discuss additional data input.

The information outline will then undergo a screening process, and, in some cases, actual testing of candidate systems may be required. At a future date, Olson may request that you make your retrofit system available for testing.

A nondisclosure agreement is provided to maintain the security of your device (Enclosure 3). Please sign and return one copy to OLI. We wish to assure you that all detailed design data with respect to your system will remain confidential and that only performance data will be disclosed in the final report to EPA.

Should there be any questions regarding the completion of the retrofit information outline, please feel free to contact Mr. Matt Bornyasz at the OLI test center in Anaheim, California - (714) 871-3920.

Sincerely,

Milton J. Webb
Project Engineer

MJW/j

Enclosures 3

September 27, 1971

Enclosure 1

RETROFIT INFORMATION OUTLINE

A retrofit information outline and data format are provided to assist you in presenting information with regard to your retrofit system and to assist OLI in the evaluation. The retrofit information outline is divided into four categories:

1. System Information
2. Performance Data
3. Estimated Cost Information
4. Marketing Plan

A glossary of terms and instructions for the retrofit evaluation are included in Enclosure 2. In cases where the requested data are not available, write "none" and indicate when (or if) it will be available.

Enclosure 1

RETROFIT INFORMATION OUTLINE

1. System Information

1.1 Retrofit System Description (use extra pages or attach catalog)

- Principles of Operation ______________________________
- Installation Reqm'ts ______________________________
- Adjustments ______________________________
- MFG Techniques ______________________________

1.2 Development Status

	Number to Date
Conceptual/Design Stage	
Prototype	
Manufactured	
Distributed to Dealer	
Installed on Vehicles	
Total Accumulated Miles (Estimated, Thousands)	

1.3 Emission Control Category (check applicable box)

	Mechanical Modification						Fuel Modification	
	Exhaust Control				Crank-case Control	Fuel Evap. Control	Exhaust	Crank-case
	Induction	Ignition	Combus-tion	Exhaust				
Hydrocarbon								
Carbon Monoxide								
Oxides of Nitrogen								
Particulates								
Other								

1.4 Automotive Adaptability (Attach catalog if available)

Light Duty Vehicles Less Than 6000 Lb GVW

	AMC	Chrysler	CM	Ford	Foreign (Specify)
Year (Range)					
Engine CID (Range)					
Number of Retrofit Model Types to Satisfy Application					

2. Performance Data

Enclosure 1 cont.

2.1 Exhaust Emission Performance (Avg Value if More than One Test. Please Attach Supporting Data).

Please attach additional test data if available	Exhaust Emission Measurements, Fill In Applicable Blanks									
	7-Mode Hot-Start _____ 7-Mode Cold-Start _____			Federal Tests 1970 _____ 1972 _____			Other Tests (specify units and test conditions)			Particulates
	HC, PPM	CO, %	NO_x, PPM	HC, GPM	CO, GPM	NO_x, GPM	HC, ___	CO, ___	NO_x, ___	_____
Baseline, as received										
Baseline, after tune-up										
Retrofit device test										
Number of cars										
Test source										
Additional test data										
Durability Fleet Test Data (Attach Data If Available)										

2.2 Special Reqm'ts., if any (Fuel,Safety)____________________

2.3 Reliability (mean mileage between failure, MMBF)

MMBF Miles	Confidence	Test Source

2.4 Maintainability (mean time to repair, MTTR)

MTTR, Hours			Parts Required for Repair

2.5 Periodic Maintenance/ Inspection Requirements ____________________

2.6 Drivability Evaluation-Retrofit Device Installed: Please Conduct Evaluation and Check Applicable Boxes. See Enclosure 2 For Drivability Procedure, Page 4.

Make __________ Year_______ Engine CID_______Transmission ☐ M ☐ A

Ambient Temperature ______ °F

Car Preparation Data

Basic Ignition Timing ____Degrees

Point Dwell _____Degrees

Other Special Adjustments: Attach Data Sheet

		Idle Mode				Accel. Mode						Cruise			Decel	
		Engine RPM	Satisfactory	Rough	Stall	Satisfactory	Detonation	Stretchiness	Stumble	Hesitation	Sag	Satisfactory	Surging	Detonation	Stall	Backfire
Cold Start/Idle	Soak 12 hours minimum															
	Start to run time_____sec															
	No. of attempts_______															
	Choke Hi-cam (N) 20 sec	☐	☐	☐	☐											
	Kickdown (N) 10 sec	☐	☐	☐	☐											
	In drive, 10 sec	☐	☐	☐	☐											
Cold Start Drive-Away	Accel 0-30 (1/2 throttle)					☐	☐	☐	☐	☐	☐					
	Cruise 30 (0.1 Mile)											☐	☐	☐		
	Accel 30-55 (WOT at Detent)					☐	☐	☐	☐	☐	☐					
	Decel 55-15 (Mod Brake)														☐	☐
	Cruise 15 (0.1 Mile)											☐	☐	☐		
	Accel 15-50 (1/2 Throttle)					☐	☐	☐	☐	☐	☐					
	Cruise 50 (0.1 Mile)											☐	☐	☐		
	Decel 50-0 (Mod Brake)														☐	☐
	Idle, 15 Seconds	☐	☐	☐	☐											

Stop Engine, Soak 15 Min, Restart: Start Time_____Sec, Attempts _______

		Idle Mode				Accel. Mode						Cruise			Decel	
Hot Start Evaluation	Idle, 15 Seconds	☐	☐	☐	☐											
	Accel 0-30 (1/2 Throttle)					☐	☐	☐	☐	☐	☐					
	Cruise 30 (0.1 Mile)											☐	☐	☐		
	Accel 30-55 (WOT at Detent)					☐	☐	☐	☐	☐	☐					
	Decel 55-15 (Mod Brake)														☐	☐
	Cruise 15 (0.1 Mile)											☐	☐	☐		
	Accel 15-50 (1/2 Throttle)					☐	☐	☐	☐	☐	☐					
	Cruise 50 (0.1 Mile)											☐	☐	☐		
	Decel 50-0 (Mod Brake)														☐	☐
	Idle, 15 Seconds	☐	☐	☐	☐											

Performance	Trial 1	Trial 2	Trial 3
WOT Accel 0-60, Sec			
Decel 60-30, Sec			

Comments ______________________

____

____

____

Enclosure 1 cont.

3. Estimated Cost Information, Dollars

3.1 Retrofit System Cost	Cost	Quantity
. Initial Cost		
. Developmental/Prototype		
. Manufacturing		
. Distribution		

3.2 Profit Margins		
. Manufacturer		
. Distributor		
. Dealer/Installer (Retail)		

3.3 Installation on Vehicle		
. Kit/Parts		
. Labor, Hours		

3.4 Recurring Retrofit Costs

. Fuel Economy , miles/gallon	Baseline	Retrofit
City		
Highway		
Composite		
. Parts Replacement Cost		

4. Marketing Information/Plan ____

____

____

____

Enclosure 2

RETROFIT EVALUATION GLOSSARY
AND INSTRUCTIONS

This glossary contains typical terms that will be used in the OLI Retrofit Evaluation Process. The headings and numbers correspond to those used in the information outline (Enclosure 1). A retrofit device is any system or modification which may be incorporated on a light duty gasoline powered vehicle (6000 lbs GVW max) whose primary function is to reduce emissions. Specifically excluded are:

- regular vehicle maintenance and/or tune-up
- the General Motors, Chrysler and Ford retrofit systems
- inspection programs such as visual and/or measured emissions

Note: Other programs are currently evaluating the above exclusions.

1. System Information

1.1 System Description: Design information includes principles of operation, the physical description and materials, and manufacturing features. Schematic diagrams, engineering drawings, sketches, and photographs should be included where possible. Installation, adjustment procedures, and test equipment requirements should also be included. Construction features such as materials and manufacturing techniques should be supplied.

1.2 Development Status: The status of the system with regard to its stage of development is requested. If the system is actually in production, an estimate of the number of vehicle installations and the total accumulated miles should be included.

1.3 Emission Control Category:

Induction Modification - A retrofit emission control system which is installed upstream from the combustion chamber. Examples include carburetor and intake manifold modifications.

Ignition Modifications - A retrofit emission control system that modifies the standard ignition system. Examples include timing advance and electrical circuit modifications.

Combustion Modification - A retrofit emission control system that modifies the combustion process inside the combustion chamber. An example of this would include valve timing modification.

Crankcase Control Modification - A retrofit emission control system that controls crankcase blowby emissions.

Fuel Evaporation Control Modification - A retrofit emission control system that controls fuel evaporation from the fuel tank and/or carburetor.

Fuel Modification - Fuel additives added to the fuel that modifies engine or crankcase deposit characteristics.

1.4 Adaptability: Adaptability information identifies the particular vehicle make/model/engine applications.

2. Performance Data - Performance data includes emission testing, reliability, maintainability and drivability. Emission data by the 1972 Federal and/or 7-mode procedures are requested. System reliability and maintainability information should be expressed in terms of design goals and actual measured values. Since there is no one standard drivability procedure OLI requests that you conduct this test as outlined in Enclosure 2 for the initial evaluation.

2.1 Exhaust Emission Performance:

Emission - Emission criteria is in terms of hydrocarbons, carbon monoxide (CO), nitrogen oxides (NO_x), or particulates (if applicable) from vehicle exhaust. Units of measurement include concentration (ppm or %) and mass (grams per mile).

Baseline - The reference or initial starting point from which future tests will be compared.

As Received - No changes, alterations, or adjustments incorporated upon receipt of the test vehicle.

Tune-up - Inspection, repair, adjustment, and/or component replacement necessary to meet the automobile manufacturer's specifications.

Retrofit Device Test - Test results with retrofit device installed and operating.

Test Source - The name of the company who conducted the exhaust emission tests.

Durability Fleet Tests - Measured exhaust emissions versus mileage and applicable durability test data such as fuel and oil consumption. Attach separate data summaries if available.

2.2 Special Requirements: Special requirements to operate the retrofit device with respect to fuel and/or safety.

2.3 Reliability: Expressed in terms of the mean time (mileage) between loss of emission control or vehicle operation impairment as a function of the retrofit system due to failure and/or service requirements.

2.4 Maintainability: Expresses the required effort to repair, service, or otherwise maintain the retrofit in an operational condition, quantified by mean time to repair (MTTR) in hours.

2.5 Periodic Maintenance: Specify the required normal maintenance and inspection requirements.

2.6 Drivability Glossary:

Surging is evidenced by periods of short duration in which a decrease in power occurs, resulting in a decrease in rate of acceleration or a float period at road load condition.

Stretchiness is less than normal acceleration when throttle is opened gradually.

Hesitation is a momentary pause in the rate of acceleration.

Sag is a momentary drop-off in acceleration rate; it does not occur immediately after the throttle application (as in hesitation), but after vehicle has acquired some speed.

Stumble is a momentary abrupt deceleration during an acceleration.

Carburetor Kickdown is a moderate depressing of accelerator pedal to change engagement of choke fast idle speed screw from the high step to a lower step of cam.

Induction Backfire is an explosion observed through the carburetor.

Exhaust Backfire is an explosion observed through the exhaust system.

Detonation is ignition knock or "pinging" during acceleration or cruise modes.

Stall is when the engine stops (without turning off the ignition switch) and must be restarted.

WOT is wide open throttle.

Vehicle Drivability Procedure

Introduction

This road test drivability procedure for cold-start, hot-start and drive-away evaluation was developed for the retrofit program. The test course requires approximately one mile of level road with minimum traffic loads. The drivability evaluation requires both a driver and an observer. Please practice the driving cycle before attempting to record actual test data.

Test Vehicle Preparation

1. Set vehicle to manufacturer's specifications including idle speed, idle mixture, ignition timing, choke setting prior to drive-away testing. Record setup information on drivability evaluation form (Enclosure 1). If special adjustments are required for the operation of your system, record in the comments.
2. Install tachometer.
3. Lock out "overdrive" operation on overdrive equipped vehicles.
4. Park vehicle outside where it can be driven forward without steering maneuvers.
5. Soak vehicle for a minimum of 12 hours.

Cold-Starts

1. Depress accelerator pedal to set choke per owner's manual starting instructions.
2. Start engine and record engine-to-run or start time (on manual transmission models, select neutral and maintain clutch pedal in depressed position until engine is started; then release clutch).
3. Turn on headlamps (high beam).
4. Permit engine to idle in neutral 20 seconds on the top step (hi-cam) of the fast idle cam. Record idle rpm and quality. If idle is rough or stall occurs, record on data sheet.

Note: If engine stalls during the above steps, repeat the starting procedure.

Kickdown Carburetor: At the end of the initial 20 second warm-up period, depress the accelerator pedal to increase engine speed to approximately 1500 rpm (neutral) and immediately release to permit fast idle screw to fall on a lower step of the fast idle cam. Record idle rpm and quality after ten seconds.

1. For manual transmission equipped vehicles, record idle rpm in neutral.

2. For automatic transmission equipped vehicle, move shift selector to drive. Record idle rpm and quality after ten seconds.

Note: If the engine stalls during the above steps, repeat the starting procedure and make notes in comment section.

Cold Start Drive-Away: Prior to the execution of drive-away, set heater (or air conditioner) blower motor on high speed and leave headlights on.

1. Release parking brake.

2. Make drive-away at 1/2 throttle travel to 30 mph. Manual transmission shift operations will be performed at 15 and 25 mph.

3. Continue to drive vehicle until testing has been completed following the steps listed under Cold Start Drive-Away on the data sheet. During this period, note and record the applicable matrix box for each mode of operation.

4. Record idle rpm and quality at end of test (with clutch pedal released for manual transmission or "drive" for automatic transmission).

5. Park vehicle where it can be driven forward without steering maneuvers. Turn off ignition and headlamps. Soak vehicle for 15 minutes. Do not raise hood during or after soak.

Hot-Start

1. Depress accelerator 1/4 throttle travel and hold.

2. Start engine and run at 1500 rpm for two seconds. Record start time for engine to run.

3. Turn on headlamps (high beams) and heater or air conditioning.

4. Record idle rpm and quality. In neutral (clutch pedal released) for manual transmission or drive for automatic transmission.

5. Repeat Sections 1, 2, 3, 4 of the cold start drive-away procedure

6. Conduct wide open throttle (WOT) accelerations and decelerations times as noted on data sheet.

3. Estimated Cost Information

3.1,2 Initial Cost is the cost of the retrofit at the retail level and includes development, manufacturing, and distribution costs as well as profit margins.

3.3 Installation Time is the time required to install and adjust the retrofit system on a vehicle.

3.4 Recurring Cost is the cost of operation with the retrofit system installed including parts cost and changes in fuel consumption.

4. Marketing: Marketing information should include plans for distribution, franchising, training, and spare parts support of the system in the field. It is recognized that cost and marketing information may be in the form of gross estimates or plans.

Enclosure 3

NONDISCLOSURE AGREEMENT FOR THE "RETROFIT" PROGRAM
EPA CONTRACT NO. 68-04-0038

OLSON LABORATORIES, INCORPORATED
22805 Michigan Avenue
Dearborn, Michigan 48124

and

500 East Orangethorpe Avenue
Anaheim, California 92801

NONDISCLOSURE AGREEMENT made this first day of August, 1971 between Olson Laboratories, Incorporated, hereinafter called "OLI" and ______________________________ hereinafter called the "RETROFIT DEVELOPER."

The parties mutually agree to the following:

1. OLI agrees under the terms and conditions set forth herein to conduct a preliminary screening evaluation of the "RETROFIT DEVELOPER'S" emission control system.

2. The evaluation will be conducted during the period commencing on or about the first day of August, 1971 and terminating on or about the first day of February, 1972. If emission control system hardware is submitted for evaluation, it will be returned to the Retrofit Developer at the conclusion of the program.

3. The evaluation covered under 1 (above) will be performed at no cost to the Retrofit Developer.

4. OLI agrees to maintain the security of the Retrofit Developer's device and hold the results of the preliminary screening evaluation in confidence and not to divulge them to any other party without authorization in writing from the Retrofit Developer except as required to fulfill contractual commitments to the Environmental Protection Agency (EPA), Contract No. 68-04-0038. Retrofit device design data will not be disclosed to harm the Retrofit Developer's interest in the device.

OLI shall not be liable for disclosure of any such information or data if the same is:

1. in the public domain
2. disclosed inadvertently despite the exercise of the measure of care as OLI takes to preserve or safeguard its own proprietary information;
3. becomes known to OLI without similar restrictions from a source other than the originating party; or
4. disclosed after a period of five (5) years.

5. The RETROFIT DEVELOPER agrees not to use the OLI name in connection with any advertising or sales promotional purposes without specific prior approval of OLI in writing.

6. It is agreed and understood that OLI is acting as an independent contractor in the performance of any and all work hereunder and shall except for intentional, willful or grossly negligent acts of Retrofit Developer, its agents or servants, be solely liable and responsible for the payment of all legal claims for damages made by its employees or agents, on account of any property damage or personal injury arising or growing out of or in connection with the performance of this NONDISCLOSURE AGREEMENT or any omission in connection therewith.

IN WITNESS WHEREOF, the Parties hereto have set their hands.

____

____
RETROFIT DEVELOPER

____
Address

____
Signature Date

____
Title

OLSON LABORATORIES, INCORPORATED

22805 Michigan Avenue

Dearborn, Michigan 48124

500 East Orangethorpe Avenue

Anaheim, California 92801

8/21/71
Signature Date

Director of Testing
Title

APPENDIX E

EXCERPTS FROM CALIFORNIA HEALTH AND SAFETY CODE APPLICABLE TO RETROFIT METHODS FOR VEHICLE EMISSION CONTROL

Note: This appendix is an example of current legislation at the State level of Government on standards and regulations for used car retrofit emission control

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CALIFORNIA AIR POLLUTION CONTROL LAWS

(Excerpts from California Health and Safety Code, including Chapter 2, Air Pollution Control Districts, Article 1, Creation and Functioning of Districts; Article 2, Officers; Article 2.5, Claims; Article 3, Prohibitions; Article 4, Rules and Regulations; Article 5, Variances; Article 6, Procedure; Article 7, Unified Air Pollution Control Districts; Article 8, Advisory Council; Article 10, Enforcement; Article 10.5, Misdemeanors; Article 11, Rules and Regulations; Article 12, Variances; Article 13.6, Forfeitures; Article 14, Financial Provisions.)

**Administering Agency: California Air Resources Board
1108 14th Street
Sacramento, Calif. 95814**

Chapter 2

AIR POLLUTION CONTROL DISTRICTS

Article 1. CREATION AND FUNCTIONING OF DISTRICTS

24198. Legislative finding and declaration. The Legislature finds and declares that the people of the State of California have a primary interest in atmospheric purity and freedom of the air from any air contaminants and that there is pollution of the atmosphere in many portions of the State which is detrimental to the public peace, health, safety, and welfare of the people of the State.

24199. Legislative findings. The Legislature hereby finds and declares:

(a) That in portions of the State the air is polluted with smoke, charred paper, dust, soot, grime, carbon, noxious acids, fumes, gases, odors, particulate matter, and other air contaminants.

(b) That it is not practical or feasible to prevent or reduce such air contaminants by local county and city ordinances.

(c) That in other portions of the State the air is not so polluted.

(d) That it is necessary, therefore, to provide for air pollution control districts in those portions of the State where regulations are necessary and feasible to reduce air contaminants in order to safeguard life, health, property and the public welfare and to make possible the comfortable enjoyment of life and property.

24200. Air pollution control district. In each county there is hereby created an air pollution control district.

24201. Boundaries of district. The boundaries of every air pollution control district shall be coextensive with the boundaries of the county within which it is situated.

24202. Resolution of county board of supervisors. An air pollution control district shall not transact any business or exercise any of its powers under this chapter until or unless the board of supervisors of the county in which it is situated, by proper resolution, declares at any time hereafter that there is need for an air pollution control district to function in such county.

24203. Hearing on need for functioning of district. The board of supervisors at any time on its own motion may hold a public hearing to determine whether or not there is need for an air pollution control district to function.

24204. Notice of hearing; publication. The board of supervisors shall give notice of the time and place of a public hearing to determine whether or not there is need for an air pollution control district to function by publication once in a newspaper of general circulation not less than 15 days before, and not more than 45 days before such hearing.

24205. Resolution of need; grounds; commencement of function. The board of supervisors may adopt a resolution declaring that there is need for an air pollution control district to function if from the evidence received at such a public hearing it finds:

(a) That the air within such county is so polluted, or is likely to become so polluted, with air contaminants as to be injurious to health, or an obstruction to the free use of property, or offensive to the senses of a considerable number of persons, so as to interfere with the comfortable enjoyment of life or property.

(b) For any reason it is not practical to rely upon the enactment or enforcement of local county and city ordinances to prevent or control the emission of smoke, fumes, or other substances which cause or contribute to such pollution.

Upon the adoption of this resolution the district shall begin to function.

24206. Sufficiency of resolution. A resolution declaring that there is need for an air pollution control district to function is sufficient if it finds that there is need for an air pollution control district to function, and finds in substantially the wording of Section 24205 that both of the enumerated conditions exist. No further detail is necessary.

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24207. Admissibility of certified copy of resolution as evidence. A copy of a resolution declaring that there is need for an air pollution control district, duly certified by the county clerk, is admissible in evidence in any suit, action or proceeding.

24208. Air contaminant defined. As used in this chapter, "air contaminant" includes smoke, charred paper, dust, soot, grime, carbon, noxious acids, fumes, gases, odors or particulate matter, or any combination thereof.

24209. Appropriation of funds. The board of supervisors of a county in which an air pollution control district has been authorized to transact business and exercise its powers, may from time to time appropriate funds to such air pollution control district which funds shall be deposited in the treasury of such air pollution control district.

24210. Legal charge against county. All such appropriations are legal charges against the county.

24211. Corporate and politic body. Every air pollution control district is a body corporate and politic.

24212. Powers of district. Upon the adoption by the board of supervisors of a resolution declaring that there is need for an air pollution control district to function the air pollution control district in that county shall have power:

(a) To have perpetual succession.

(b) To sue and be sued in the name of the district in all actions and proceedings in all courts and tribunals of competent jurisdiction.

(c) To adopt a seal and alter it at its pleasure.

(d) To take by grant, purchase, gift, device, or lease, hold, use, enjoy, and to lease or dispose of real or personal property of every kind within or without the district necessary to the full exercise of its powers.

(e) To lease, sell or dispose of any property or any interest therein whenever in the judgment of the air pollution control board such property, or any interest therein, or part thereof, is no longer required for the purposes of the district, or may be leased for any purpose without interfering with the use of the same for the purposes of the district, and to pay any compensation received therefor into the general fund of the district.

24213. Termination of district; inclusion within district created by special law. An air pollution control district which is situated in any county included within another air pollution control district created by special law shall cease to function and exercise its powers upon the date of any rules and regulations adopted by the governing body of such special district.

24214. Termination of district; disposition of property; transfer of funds. When an air pollution control district ceases to function and exercise its powers pursuant to Section 24213, the property of such district shall vest in the county in which the district is located, and any funds belonging to such district at the time shall be transferred to such county and may be used for general county purposes.

Article 2. OFFICERS

24220. Air pollution control board; ex officio. The board of supervisors of a county shall be, and they are hereby designated as, and empowered to act as, ex officio the air pollution control board of the air pollution control district in such county.

24221. Officers and employees; ex officio; compensation. All county officers, their assistants, clerks, deputies, and employees, and all other county employees, respectively, of the air pollution control district in the county by which they are employed. Except as otherwise provided in this article, they shall perform respectively the same various duties for the air pollution control district as for the county without additional compensation, in order to carry out the provisions of this chapter.

24222. Air pollution control officer. The air pollution control board shall appoint an air pollution control officer.

24223. Appointment of assistants, deputies, and other employees. The air pollution control board may provide for assistants, deputies, clerks, attaches, and other persons to be employed by the air pollution control officer, and the times at which they shall be appointed.

24224. Duties of control officer. The air pollution control officer shall observe and enforce, within his air pollution control district:

(a) The provisions of this chapter and Chapter 3.5 (commencing with Section 39077) of Part 1 of Division 26, and all provisions of the Vehicle Code relating to the emission or control of air contaminants.

(b) All orders, regulations, and rules prescribed by the air pollution control board of the air pollution control district pursuant to this chapter.

(c) All variances and standards which the hearing board has prescribed pursuant to Article 5 (commencing with Section 24291) of this chapter.

24225. Hearing board; appointment; qualifications of members. The air pollution control board shall appoint a hearing board to consist of three members, none of whom is otherwise employed by the air pollution control district or by the county. Two members shall have been admitted to practice law in this State. One member shall be a chemical or mechanical engineer.

24226. Terms of hearing board members. The air pollution control board shall appoint one member of the hearing board for a term of one year, one for a term of two years, and one for a term of three years. Thereafter the terms of members of the hearing board shall be three years.

24227. Compensation. The air pollution control board shall determine the compensation of, and pay from district funds, the air pollution control officer, all of his assistants, deputies, clerks, attaches, and other employees, and members of the hearing board.

24227.5 Civil service; compatibility with county wage schedule; application of section. In fixing compensation to be paid to persons subject to the civil service provisions of this article, the air pollution control board, in each instance, shall provide a salary or wage equal to the salary or wage paid to county employees for the same quality of service.

This section shall be operative only in those counties which are operating under freeholders' charters which require that in the fixing of salaries or wages for persons employed by the county subject to the civil service system notice of a hearing, issue, or provide for the issuance by the hearing board, after notice and a hearing, of, an order for abatement whenever the district finds that any person is in violation of Section 24242 or 24243 or any rule or regulation prohibiting or limiting the discharge of air contaminants into the air. The air pollution control board in holding hearings on the issuance of orders for abatement shall have all powers and duties conferred upon the hearing board in this chapter. The hearing board in holding hearings on the issuance of orders for abatement shall have all powers and duties conferred upon it by this chapter.

24261. **Hearing; notice; publication; posting.** The air pollution control board shall not enact any order, rule or regulation until it first holds a public hearing thereon. It shall give not less than 10 days' notice of the time and place of such public hearing by publication in a newspaper of general circulation published within the district if such a newspaper is published within the district. If no newspaper of general circulation is published within the district it shall give notice of the time and place of public hearing by posting in a public place not less than 10 days before such hearing.

24262. **Reduction of air contaminants.** Whenever the air pollution control board finds that the air in the air pollution control district is so polluted as to cause any discomfort or property damage at intervals to a substantial number of inhabitants of the district, the air pollution control board may make and enforce such orders, rules, and regulations as will reduce the amount of air contaminants released within the district.

24263. **Permits for construction, alteration, replacement, or operation of contrivance issuing air contaminant; savings clause.** The air pollution control board may require by regulation that before any person either builds, erects, alters, replaces, operates, sells, rents, or uses any article, machine, equipment, or other contrivance specified by such regulation the use of which may cause the issuance of air contaminants, such person shall obtain a permit to do so from the air pollution control officer.

Insofar as the regulations do not grant an automatic permit for the operation or use of any article, machine, equipment, or contrivance in existence upon the effective date of such regulations, a permit shall not be required without first affording the owner, operator, or user thereof a reasonable time within which to apply for such permit, and to furnish the air pollution control officer the information required pursuant to Section 24269.

24263.7 Reduction or control of air contaminants; motor vehicle equipment; standards of performance; regulating sale. The air pollution control board by regulation may: (a) Establish standards of performance for any article, device, equipment, or method specifically designed or intended for installation or use upon or in any motor vehicle as defined in the Vehicle Code, for the purpose of eliminating, reducing or controlling the issuance of air contaminants.

(b) Prohibit the sale, offering for sale or installation of any article, device, equipment or method specifically designed or intended for installation or use upon or in any motor vehicle as defined in the Vehicle Code to eliminate, reduce, or control the issuance of air contaminants, unless such article, device, equipment or method is of a type which has been submitted to and approved by the air pollution control officer as meeting the minimum standard of performance as authorized in this section. Upon approval the air pollution control officer shall issue a permit authorizing the sale, offering for sale or installation of any said approved article, device, equipment or method referred to in this section.

24263.8 Installation of exhaust emission control devices on 1955 through 1965 model year motor vehicles.

(a) If the evidence submitted at a public hearing indicates that in order to preserve the ambient air quality of the air pollution control district it is necessary that every 1955 through 1965 model year motor vehicle within the district be equipped with device or devices certified or accredited by the State Air Resources Board to control emission of pollutants from the crankcase and exhaust, the air pollution control board may adopt rules and regulations to require the installation of such devices. Installation of exhaust emission control devices shall not be required until one year has elapsed after the State Air Resources Board, pursuant to Section 39176, has determined that such devices are available for installation.

(b) The rules and regulations shall provide for a schedule of installation by which the motor vehicles are to be equipped with the emission control device, taking into consideration the number of motor vehicles to be equipped, the availability of such devices, and the availability of licensed installers to install such devices.

(c) The air pollution control board shall coordinate its activities pursuant to this section with the Department of the California Highway Patrol and the Department of Motor Vehicles in order to insure adoption of procedures which will facilitate enforcement of the rules and regulations adopted pursuant to this section.

(d) The air pollution control board may not adopt any rule or regulation pursuant to subdivision (a) if the air pollution control district is lying within a regional air pollution control district which has adopted rules and regulations pursuant to subdivision (a) of Section 24354.14 or 39392.

(e) In the case of the air pollution control district lying in more than one regional air pollution control district, the air pollution control board, notwithstanding subdivision (d), may adopt rules and regulations pursuant to subdivision (a) for that portion of the air pollution control district lying within a regional air pollution control district which has not adopted rules and regulations pursuant to subdivision (a) of Section 24354.14 or 39392.

24264. Requirements of plans and specifications and permit. The air pollution control board may require that before the air pollution control officer issues a permit to build, erect, alter, or replace any equipment, that the plans and specifications show, and that the permit issued by the air pollution control officer require, that such building, erection, alteration, or replacement will be done in such a manner, and that such approved equipment be used as the air pollution control board finds will eliminate or reduce the discharge of any air contaminants.

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24265. Equipment exempt from permit. A permit shall not be required for:

(a) Any vehicle as defined in the Vehicle Code.

(b) Any structure designed for and used exclusively as a dwelling for not more than four families.

24265.5 Agricultural operations; regulations establishing exemptions or authorizing continued use; duration of section. The air pollution control board of any district which is activated after the effective date of this section may, by regulation, establish reasonable exemptions from the provisions of this chapter and Chapter 3.5 (commencing with Section 39077) of Part 1 of Division 26, or permit the continued use within the district for reasonable periods, of orchard heaters that produce unconsumed * * * solid carbonaceous material at a rate in excess of one gram per minute and which are then owned by persons engaged in agricultural operations within the district if the board determines that the provisions of the chapter would otherwise preclude the use of such orchard heaters in the district and would cause serious economic hardship to the owners of the heaters or the practical elimination of agricultural operations now being carried on within the district.

This section shall remain in effect until the 61st day after the final adjournment of the 1972 Regular Session of the Legislature, and shall have no force or effect after that date.

24266. Contracts with county and cities for performance of permit service. The air pollution control board may contract with the county, and may contract with any city within the air pollution control district, and the county and any such city may contract with the air pollution control district, for the performance of such work in the name of, and subject to the approval of, the air pollution control officer by the building department or other officer, department, or agency of the county or such city charged with the enforcement of regulations pertaining to the erection, construction, reconstruction, movement, conversion, alteration, or enlargement of buildings or structures, as will accomplish all or part of the purposes of Sections 24263 and 24264. The contract may provide for the consideration, if any, which the air pollution control district shall pay to such city.

24267. Permit fees. The air pollution control board may provide by regulation a schedule of fees not exceeding the estimated cost of issuing such permits and inspection pertaining to such issuance to be paid for the issuance of such permits. Every person applying for a permit shall pay the fee required by such schedule.

24268. Disposition of fees. A contract entered into pursuant to Section 24266 may provide that fees for permits shall be paid to the city, the officer, department, or agency of which city issues the permit, and may be retained by such city in whole or in part as the consideration, or part thereof, for issuing such permits. Otherwise, all fees paid for the issuance of permits shall be paid into the district treasury.

24269. Authority to require information from permit holder or applicant. The air pollution control officer at any time may require from an applicant for, or holder of any permit provided for by the regulations of the air pollution control board, such information, analyses, plans, or specifications as will disclose the nature, extent, quantity, or degree of air contaminants which are or may be discharged by such source.

24270. Suspension of permit for refusal to furnish information; notice of suspension. If the holder of any permit provided for by the regulations of the air pollution control board within a reasonable time wilfully fails and refuses to furnish to the air pollution control officer information, analyses, plans, or specifications requested by such air pollution control officer, the air pollution control officer may suspend the permit. He shall serve notice in writing of such suspension and the reasons therefor on the permittee.

24271. Demand for hearing. Within 10 days after receipt of notice of suspension the permittee may file with the hearing board a demand for a public hearing as to whether or not the permit was properly suspended.

24272. Reinstatement upon furnishing of information. The air pollution control officer shall reinstate a suspended permit when all information, analyses, plans, and specifications are furnished.

24273. Reinstatement for other reasons. The air pollution control officer may reinstate a suspended permit where, in his opinion, good reasons exist therefor.

24274. Request for public hearing on revocation or reinstatement of suspended permit. The air pollution control officer may request the hearing board to hold a public hearing to determine whether a permit should be revoked, or a suspended permit should be reinstated.

24275. Hearing; notice. Within 30 days after either the air pollution control officer or the permittee has requested a public hearing, the hearing board shall hold such a hearing and give notice of the time and place of such hearing to the permittee, to the air pollution control officer and to such other persons as the hearing board deems should be notified, not less than 10 days before the date of the public hearing.

24276. Powers of hearing board. After a public hearing, the hearing board may:

(a) Continue the suspension of a permit suspended by the air pollution control officer, or

(b) Remove the suspension of an existing permit invoked by the air pollution control officer pending the furnishing by the permittee of the information, analyses, plans, and specifications required, or

(c) Find that no violation exists and reinstate an existing permit, or

(d) Revoke an existing permit, if it finds:

(1) The permittee has failed to correct any conditions required by the air pollution control officer, or

(2) A refusal of a permit would be justified, or

(3) Fraud or deceit was employed in the obtaining of the permit, or

(4) Any violation of this chapter, Chapter 3.5 (commencing with Section 39077) of Part 1 of Division 26, or of any rule or regulation of the air pollution control board.

24277. False statements; misdemeanor. Every person is guilty of a misdemeanor who knowingly makes any false entirely submerged when the liquid level is six inches above the bottom of the tank. "Submerged fill pipe," when applied to a tank which is loaded from the side, means any fill pipe which has its discharge opening entirely submerged when the liquid level is 18 inches above the bottom of the tank.

(f) Subdivisions (a) and (b) shall not apply to any stationary tank which is used primarily for the fueling of implements of husbandry, as such vehicles are defined in Division 16 (commencing with Section 36000) of the Vehicle Code. (Amended September 17, 1970)

39068.3. A "pressure tank" is a tank which maintains working pressure sufficient at all times to prevent hydrocarbon vapor or gas loss to the atmosphere. (Amended September 17, 1970)

39068.4 A "vapor recovery system" consists of a vapor gathering system capable of collecting the hydrocarbon vapors and gases discharged and a vapor disposal system capable of processing such hydrocarbon vapors and gases so as to prevent their emission to the atmosphere, with all tank gauging and sampling devices gastight except when gauging or sampling is taking place. (Amended September 17, 1970)

39068.5. A "floating roof" consists of a pontoon-type or double-deck-type roof, resting on the surface of the liquid contents and equipped with a closure seal, or seals, to close the space between the roof edge and tank wall. The control equipment provided for in this section shall not be used if the gasoline or petroleum distillate has a vapor pressure of 11.0 pounds per square inch absolute or greater under actual storage conditions. All tank gauging and sampling devices shall be gastight except when gauging or sampling is taking place. (Amended September 17, 1970)

39069. There is established in this state the California Environmental Protection Program, which shall be concerned with preserving and the protection of California's environment, including, but not limited to, the control and abatement of air pollution generated by motor vehicles. All phases or research into the sources, dynamics and effects of environmental pollutants generated by motor vehicles shall fall within the purview of the program.

39070. The Secretaries of the Resources and Business and Transportation Agencies are responsible for the development of the California Environmental Protection Program and the determination of the priorities of such program.

39071. The California Environmental Protection Program Fund is hereby created in the State Treasury consisting of the moneys deposited in the fund pursuant to Article 8.5 (commencing with Section 5100) of Chapter 1 of Division 3 of the Vehicle Code. Amounts equal to the actual costs incurred by the Department of Motor Vehicles in performing its duties pursuant to Article 8.5 are hereby continuously appropriated from the fund to the department, and shall be transferred to, and in augmentation of, the appropriation from which such costs were paid. The balance of the moneys in such fund shall be available for expenditure for the purposes and uses of the California Environmental Protection Program upon appropriation by the Legislature.

39072. The secretaries may recommend an apportionment of any funds contained in the California Environmental Protection Program Fund among various state agencies, local political subdivisions, the University of California, and any private research organization as shall effectuate the purposes of the program.

39073. The secretaries may recommend an allocation of any funds to carry out projects within the program, including, but not limited to, capital outlay projects.

39074. The funds provided for in Section 39071 may be used in a manner which will allow the state to qualify for any funds which may be available from any source for the purpose of carrying out the provisions of this chapter.

CHAPTER 3.5 NONVEHICULAR POLLUTION CONTROL

39077. No person shall discharge from any nonvehicular source whatsoever such quantities of air contaminants or other material which cause injury, detriment, nuisance or annoyance to any considerable number of persons or to the public or which endanger the comfort, repose, health or safety of any such persons or the public or which cause or have a natural tendency to cause injury or damage to business or property.

39077.1. No person shall discharge into the atmosphere from any single nonvehicular source of emission whatsoever any air contaminant for a period or periods aggregating more than three minutes in any one hour which is:

(a) As dark or darker in shade as that designated as No. 2 on the Ringelmann Chart, as published by the United States Bureau of Mines, or

(b) Of such opacity as to obscure an observer's view to a degree equal to or greater than does smoke described in subdivision (a).

39077.2. No person shall, on and after January 1, 1971, operate any aircraft in such a manner that will result in the discharge into the atmosphere of any air contaminant for a period of over 10 seconds in any one hour which is:

(a) As dark or darker in shade as that designated as No. 2 on the Ringelmann Chart, as published by the United States Bureau of Mines; or,

(b) Of such opacity as to obscure an observer's view to a degree equal to or greater than does smoke described in subdivision (a).

As used in this section, "aircraft" means any contrivance used or designed for navigation of, or flight in, the air.

39077.3. Notwithstanding the provisions of Article 5 (commencing with Section 24291) of Chapter 2 of Division 20, Article 12 (commencing with Section 24365) of Chapter 2.5 of Division 20, or Article 8 (commencing with Section 39470) of Chapter 3 of Part 2 of this division, no person shall set, grant permission to set, or cause to be set, fires which would be in violation of any applicable order, rule, or regulation adopted pursuant to Sections 24262, 24362.3, or 39463.

39077.4. The provisions of Sections 39077 and 39077.1 shall not apply to smoke from fires:

(a) Set by or permitted by any public officer if such fire is set or permission given in the performance of the official duty of such officer, and such fire in the opinion of such officer is necessary:

(1) For the purpose of the prevention of a fire hazard which cannot be abated by any other means, or

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(2) For the instruction of public employees in the methods of fighting fire, or

(3) For the improvement of watershed, range, or pasture, or

(4) For the growing of crops, or raising of fowls or animals.

(b) Set pursuant to permit on property used for industrial purposes for the purpose of instruction of employees in methods of fighting fire.

(c) Set pursuant to an open burning permit issued by any air pollution control officer of any local or regional authority.

39077.5. The provisions of Sections 39077, 39077.1, and 39077.2 shall not apply to:

(a) Agricultural operations and associated odors necessary for the growing of crops or raising of fowls or animals.

(b) Use of any aircraft to distribute seed, fertilizer, insecticides, or other agricultural aids over lands devoted to the growing of crops or raising of fowls or animals.

39077.6. Each local and regional authority shall enforce the provisions of this chapter.

39077.7 Any violation of any provision of this chapter or of any order, rule, or regulation of the board or of any order, rule, or regulation of any local or regional authority may be enjoined in a civil action brought in the name of the people of the State of California, except that the plaintiff shall not be required to allege facts necessary to show or tending to show lack of adequate remedy at law or to show or tending to show irreparable damage or loss.

39078. (a) The Legislature hereby finds and declares that recent evidence indicates that lead compounds emitted into the air by nonvehicular sources accumulate in and upon vegetation in the vicinity of such sources, pose a grave threat to the health of animals which consume such vegetation, and constitute a potential human health hazard.

(b) Each local and regional district, including the Bay Area Pollution Control District, shall establish by January 1, 1972, emission standards for lead compounds emitted into the air from nonvehicular sources. In areas which are not in a local or regional district, or where the district has failed to establish such standards by the required date, the board shall establish such standards in those areas. (Amended September 17, 1970)

CHAPTER 4. MOTOR VEHICLE POLLUTION CONTROL

Article 1. Application and Definitions

39080. This chapter may be cited as the "Pure Air Act of 1968."

39081. The Legislature finds and declares:

(a) That the emission of pollutants from motor vehicles is the primary cause of air pollution in many portions of the state.

(b) That the control and elimination of such pollutants is of prime importance for the protection and preservation of the public health and well-being and for the prevention of irritation to the senses, interference with visibility, and damage to vegetation and property.

(c) That the state has a responsibility to establish uniform procedures for compliance with standards which control or eliminate such pollutants.

(d) That the California goal for pure air quality is the achievement of an atmosphere with no significant detectable adverse effect from motor vehicle air pollution on health, welfare and the quality of life and property by 1975.

(e) That vehicle emission standards applied to new motor vehicles and to used motor vehicles equipped with emission control devices are standards with which all such vehicles shall comply subject to the approval, accreditation, and certification of provisions of this part.

39082. The provisions of this chapter shall not apply to any racing vehicle, as defined in Section 39090.5.

39083. The provisions of this chapter shall not apply to any limited production motor vehicle, as defined in Section 39090.

39083.5. The provisions of this chapter shall not apply to any motorcycle as defined in Section 39084.

39084. As used in this chapter the following terms shall be construed as defined in the Vehicle Code:

(a) Commercial vehicle
(b) Implement of husbandry
(c) Motor vehicle
(d) Motorcycle
(e) Used vehicle
(f) Passenger vehicle
(g) New vehicle
(h) Truck
(i) Truck tractor
(j) Bus

39085. As used in this chapter, "approval" means the findings of the board that the device for new vehicles has satisfied the tests and procedures established by the board to determine whether the various makes and models of new motor vehicles for each model year may be sold and registered in this state. Approval shall be determined on the basis of motor vehicle emissions and such other related factors as the board may in regulations indicate.

39086. As used in this chapter, "crankcase emissions" means substances emitted directly to the atmosphere from any opening leading to the crankcase of a motor vehicle engine. Crankcase gases which are conducted to the engine intake or exhaust systems are not included in the definition of crankcase emissions, but are defined as exhaust emissions.

39087. As used in this chapter, "exhaust emissions" means substances emitted to the atmosphere from any opening downstream from the exhaust port of a motor vehicle engine.

39088. As used in this chapter, "fuel evaporative loss emissions" means vaporized fuel emitted into the atmosphere from the fuel system of a motor vehicle.

39089. As used in this chapter, "fuel system" means the combination of fuel tank, fuel lines and carburetor, or fuel injector, and includes all vents and fuel evaporative emission control systems or devices.

39090. As used in this chapter, "limited production vehicle" means a make of motor vehicle of a model year prior to 1973 which was manufactured or sold in California in quantities of less than 2,000 units for such model year, if the sales of the make of motor vehicle in California did not exceed 200 units in the 1968 calendar year. (Amended September 15, 1970)

39090.5 As used in this chapter, "racing vehicle" means a competition vehicle not used on public roads or highways.

39091. As used in this chapter, "model year" means the time of actual manufacture either (1) within the annual production period of such vehicles as designated by the calendar year in which such period ends, or (2) if the manufacturer does not so designate the annual production period of such vehicles manufactured by him, with 12-month period beginning November 1 of the preceding year. In the case of any vehicle manufactured in two or more stages, the time of manufacture shall be the date of completion of the chassis.

39092. As used in this chapter, "accreditation" means a finding by the board, pursuant to the procedures established in Article 5 (commencing with Section 39175) of this chapter, that a used motor vehicle emission control device has satisfied the tests and procedures established by the board pursuant to Sections 39107 and 39108.

39093. As used in this chapter, "motor vehicle pollution control device" means equipment designed for installation on a motor vehicle for the purpose of reducing the pollutants emitted from the vehicle, or a system or engine modification on a motor vehicle which causes a reduction of pollutants emitted from the vehicle.

39094. As used in this chapter, "certified device" means a motor vehicle pollution control device required to be installed on various motor vehicles under regulations adopted by the former Motor Vehicle Pollution Control Board prior to November 8, 1967, or under regulations adopted by the board prior to the effective date of the applicable standards provided in this part.

39095. As used in this chapter other than in Section 39094, "Motor Vehicle Pollution Control Board" means, and is applicable to, the board.

39096. As used in this chapter, the terms hydrocarbons, carbon monoxide, and oxides of nitrogen, shall be construed as defined in the regulations of the board, such definitions to be developed in accordance with the purpose of this chapter.

Article 2. Motor Vehicle Emission Standards

39100. Approval of new motor vehicles for sale and registration and accreditation of devices for used motor vehicles shall be contingent upon compliance with the standards established in this part or pursuant thereto, under the test procedures established by the board pursuant to Section 39052. Motor vehicles which do not so comply with the applicable standards shall not be sold and registered in California.

39100.1. Every manufacturer of motor vehicles sold in the State of California during the calendar year 1968 shall file with the board, not later than 60 days after the effective date of this section, a report describing such manufacturer's research and development activities, including test data, during the preceding 12 months relating to the control of oxides of nitrogen emitted from its vehicles. Where proprietary or competitive requirements necessitate, such reports shall refer to vehicles, technical innovations, and devices by code name or number. Additional progress reports shall be filed with the board by such manufacturers at three-month intervals from 60 days after the effective date of this section until July 1, 1970. Failure to submit such reports shall be considered as constituting failure of compliance under Section 39154.

39100.3. No manufacturer who pays a penalty pursuant to subdivision (m) of Section 39052 shall add the amount of such penalty to the cost of any motor vehicles sold by such manufacturer and any provision of any contract of sale including such penalty as part of the cost of a motor vehicle shall be void and unenforceable.

It is the intent of the Legislature that the Air Resources Board shall determine the total number of vehicles to be tested on the assembly line and the date that this testing shall be initiated, after having first considered preliminary data obtained from both foreign and domestic manufacturers for the purpose of verifying the testing and reporting procedures required to assure equitable application of the provisions of subdivision (m) of Section 39052 to all motor vehicle manufacturers. In making these determinations, the board must give consideration to the economic and technological feasibility of the assembly line test procedure.

39100.5. The standards in this article have been found to be technologically feasible and capable of implementation with reasonable economic cost by a technical advisory panel of nine California engineers, scientists, and air pollution experts.

39101. The exhaust emissions from a new 1970 model year gasoline-powered motor vehicle under 6,001 pounds, manufacturer's maximum gross vehicle weight rating having an engine displacement of 50 cubic inches or greater, subject to registration and first sold and registered in this state, shall not exceed:

(a) 2.2 grams per mile hydrocarbons.
(b) 23 grams per mile carbon monoxide.

39101.5. The exhaust emissions from a new 1971 model year gasoline-powered motor vehicle under 6,001 pounds, manufacturer's maximum gross vehicle weight rating having an engine displacement of 50 cubic inches or greater, subject to registration and first sold and registered in this state, shall not exceed:

(a) 2.2 grams per mile hydrocarbons.
(b) 23 grams per mile carbon monoxide.
(c) 4.0 grams per mile oxides of nitrogen.

39102. The exhaust emissions from a new 1972 or later model year gasoline-powered motor vehicle under 6,001 pounds, manufacturer's maximum gross vehicle weight rating having an engine displacement of 50 cubic inches or greater, subject to registration and first sold and registered in this state, shall not exceed:

(a) 1.5 grams per mile hydrocarbons.
(b) 23 grams per mile carbon monoxide.
(c) 3.0 grams per mile oxides of nitrogen.

39102.5 Notwithstanding the provisions of subdivision (c) of Section 39102, the oxides of nitrogen exhaust emissions from a new 1974 or later model year gasoline-powered motor vehicle under 6,001 pounds, manufacturer's maximum gross vehicle weight rating having an engine displacement of 50 cubic inches or greater, subject to registration and first sold and registered in this state shall not exceed 1.3 grams per mile oxides of nitrogen.

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39104. The exhaust emissions from a new 1970 or 1971 model year gasoline-powered truck, truck tractor or bus, except those which are diesel-powered, over 6,001 pounds, manufacturer's maximum gross vehicle weight rating, subject to registration and first sold and registered in this state, shall not exceed:

(a) 275 parts per million hydrocarbons.

(b) 1.5 percent carbon monoxide.

39105. The exhaust emissions from a new 1972 or later model year gasoline-powered truck, truck tractor or bus, except those which are diesel-powered, over 6,001 pounds, manufacturer's maximum gross vehicle weight rating, subject to registration and first sold and registered in this state, shall not exceed:

(a) 180 parts per million hydrocarbons.

(b) 1.0 percent carbon monoxide.

39106. Fuel evaporative losses from the fuel system in a 1970 or later model year gasoline-powered motor vehicle having an engine displacement of 50 cubic inches or greater, under 6,001 pounds, manufacturer's maximum gross vehicle weight rating, subject to registration and first sold and registered in this state, shall not exceed six grams hydrocarbons per test.

39107. In order for an exhaust emission device to be accredited by the board pursuant to Article 5 (commencing with Section 39175) of this chapter it shall not allow emissions exceeding any of the following:

(a) 350 parts per million hydrocarbons.

(b) 2 percent carbon monoxide.

(c) 800 parts per million nitrogen oxide.

However, if no exhaust emission device meets all three of the maximums specified in subdivisions (a), (b), and (c), the board may accredit an exhaust emission device which meets any two of the three maximums specified, provided that the installation of such device in a motor vehicle would not increase the other emission in excess of the emission of that pollutant by the vehicle in the absence of such a device.

If two or more exhaust emission devices are accredited that meet the requirements of this section, the board may not require the installation of more than one exhaust emission device on any vehicle.

39108. In order for an evaporative loss device to be accredited by the board pursuant to Article 5 (commencing with Section 39175) of this chapter, it shall not allow fuel systems evaporative loss greater than six grams hydrocarbons per test.

39109. Exhaust emission standards for hydrocarbons, carbon monoxide and oxides of nitrogen for new diesel-powered vehicles first sold and registered in this state as established by the board pursuant to subdivision (n) of Section 39052, shall apply to all such vehicles at such time as the board determines it is technologically feasible, but no later than January 1, 1973.

39110. The standards applicable under this division for exhaust emissions for gasoline-powered motor vehicles shall apply to motor vehicles which have been modified or altered to use a fuel other than gasoline or diesel.

39111. The provisions of subdivision (q) of Section 39052 of, and Section 39110 of, the Health and Safety Code and of Sections 4000.1 and 27156 of the Vehicle Code shall not be applicable to an alteration or modification to use a fuel other than gasoline or diesel completed prior to the effective date of this section.

39112. Subject to the provisions of Sections 39052, 39052.5 and 39052.6 and Article 5 (commencing with Section 39175) of this chapter, all motor vehicles required pursuant to the National Emissions Standards Act (42 U.S.C. Secs. 1857f-1 to 1857-7, inclusive) and the standards and regulations promulgated thereunder, to be equipped with pollution control devices, shall be equipped with pollution control devices required by that act.

39113. The board may approve the fuel system of any motor vehicle powered by propane, butane, or natural gas which meets the standards specified by Section 39110. (Amended September 13, 1970)

39114. Whenever any motor vehicle is required to be equipped with any pollution control device by rules and regulations adopted by any district pursuant to Section 24263.8, 24354.14, or 39392, such motor vehicle shall be equipped with such pollution control device. (Amended September 14, 1970)

Article 3. Previously Certified Devices

39125. All motor vehicles previously required to have certified pollution control devices pursuant to the provisions of Chapter 1545, Statutes of 1967, shall be required to continue to have such devices, unless otherwise specifically exempted by this chapter.

39126. The board may exempt classifications of motor vehicles subject to this article for which certified devices are not available and motor vehicles whose emissions are found by appropriate tests to meet state standards without additional equipment, and motor-driven cycles, implements of husbandry, and vehicles which qualify for special license plates under Section 5004 of the Vehicle Code.

39127. The board may revoke, suspend, or restrict a certificate of a previously certified device or an exemption previously granted upon a determination by the board that the device no longer operates within the standards set by the board or no longer meets the criteria adopted pursuant to subdivision (c) of Section 39175 or no longer should be exempted. Provided that once any motor vehicle is equipped with a certified device it shall not thereafter be deemed in violation of this chapter or of Section 27156 of the Vehicle Code, because the certification of such device is subsequently revoked, suspended or restricted, and replacement parts for such device may continue to be supplied and used for such vehicle, unless such revocation, suspension or restriction is based upon a finding that the certified device has been found to be unsafe in actual use or is otherwise mechanically defective, in which event such devices shall be brought into compliance with this chapter within 30 days after such finding.

39128. Proceedings under this chapter with respect to the granting of exemptions, or for the revocation, suspension or restriction of certificates previously issued, or exemptions previously granted, by the board, shall be conducted in accordance with the provisions of Chapter 5 (commencing with Section 11500), Part 1, Division 3, Title 2 of the Government Code, and the board shall have all the powers granted therein.

39129. The following classifications of motor vehicles are subject to the provisions of this article:

(a) Every 1966 or later years model motor vehicle subject to registration in this state shall be equipped with a certified device or devices to control emission of pollutants from the crankcase and exhaust.

(b) Every motor vehicle of 1963 or later year model, subject to registration in this state shall be equipped with a certified device to control the emission of pollutants from the crankcase.

(c) Every motor vehicle of 1955 through 1962 year model subject to registration in this state upon either transfer of ownership and registration to an owner whose residence is in a county or portion of a county within an air pollution control district which may function and exercise its powers, or upon registration of a vehicle previously registered outside this state to an owner whose residence is in a county or portion of a county within an air pollution control district which may function and exercise its powers shall be equipped with a certified device to control the emission of pollutants from the crankcase.

(d) Every motor vehicle of 1955 through 1965 year model subject to registration in this state upon transfer of ownership and registration to an owner whose residence is in a county or portion of a county within an air pollution control district which may function and exercise its powers, shall be equipped with a certified device to control the emission of pollutants from the exhaust.

(e) The provisions of subdivisions (a), (b), (c), and (d) of this section shall not be applicable to any of the following vehicles:

(1) Any motor vehicle or class of motor vehicles exempted by the board.

(2) Any motor-driven cycle, implement of husbandry or vehicle which qualifies for special plates under Section 5004 of the Vehicle Code.

(f) The provisions of subdivisions (c) and (d) shall not be applicable in any district activated after July 1, 1959, so as to be able to perform its functions unless the board of supervisors of each county or the Board of Directors of the Bay Area Regional Air Pollution Control District in which the district is situated adopts a resolution based upon its finding that subdivisions (c) and (d) are necessary to the preservation of air quality within that district; nor shall the provisions of subdivisions (c) and (d) be applicable in any county situated within a multicounty district formed prior to July 1, 1959, which county is adjacent to a district activated prior to January 1, 1960, unless the board of supervisors in such county adopts a resolution based upon its finding that subdivisions (c) and (d) are necessary to the preservation of air quality within that county. (Amended September 14, 1970)

(g) Every 1968 year model passenger vehicle, except motorcycles, subject to registration and first sold and registered in this state shall be equipped with a certified device or devices to control emission of pollutants from the crankcase and exhaust. Notwithstanding any other provision of this section or of Article 5 (commencing with Section 39175) of this chapter, the board may only grant an exemption for not to exceed 1 percent of a manufacturers' passenger vehicle sales in California in the preceding model year.

(h) Every 1967 year model commercial motor vehicle under 6,001 pounds manufacturer's maximum gross vehicle weight rating subject to registration and first sold and registered in this state shall be equipped with a certified device or devices to control emission of pollutants from the crankcase and exhaust.

(i) The provisions of subdivisions (c) and (d) of this section shall not be applicable to motor vehicles registered to an owner whose residence is in an area, designated pursuant to this subdivision, of any county having an area in excess of 7,000 square miles in which an air pollution control district consisting of a single county may function and exercise its powers and within 60 days after the effective date of this section the board of supervisors of such county has classified the county into two areas because of substantial geographic and climatic differences between the two areas, and within 60 days after the effective date of this section the board of supervisors of the county has found that within one of such areas, designated by the board, the equipment of motor vehicles with devices to control the emission of pollutants is unnecessary for the preservation of air quality within that area.

(j) Notwithstanding any provision of subdivision (f), if after the effective date of this section subdivisions (c) and (d) are made applicable to a district or county in which subdivisions (c) and (d) are inapplicable under subdivisions (f) on such effective date, subdivisions (c) and (d) shall not be applicable to any other district or county unless its governing board adopts a resolution based upon its finding that subdivisions (c) and (d) are necessary to the preservation of air quality in such other district or county, as the case may be.

39130. No person shall sell, display, advertise, or represent as a certified device any device which, in fact, is not a certified device. No person shall install or sell for installation upon any motor vehicle, any motor vehicle pollution control device which has not been certified by the board.

39131. Any manufacturer of a device required by this article shall, as a condition of certification of such device by the board, agree that so long as only one such device is certified by the board such manufacturer shall either: (1) agree to enter into such cross-licensing or other agreements as the board determines are necessary to insure adequate competition among manufacturers of such devices to protect the public interest; or (2) agree as a condition to such certification that if only one such device from one manufacturer is made available for sale to the public, the board shall, taking into consideration the cost of manufacturing the device and the manufacturer's suggested retail price, and in order to protect the public interest, determine the fair and reasonable retail price of such device and may require, as a condition to continued certification of such device, that the retail price of such device, including installation, not exceed such price as determined by the board. In either event the retail price so determined by the board for a device required by subdivision (d) of section 39129 or Section 39176 shall not be in excess of sixty-five dollars ($65) per vehicle.

Article 4. New Motor Vehicle Approval

39150. The board shall have the powers and authority necessary to carry out the duties imposed on it by this article including, but not limited to, the following:

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(a) To adopt rules and regulations in accordance with the provisions of the Administrative Procedure Act (commencing with Section 11370) of the Government Code, necessary for proper execution of the powers and duties granted to, and imposed upon, the board by this article.

(b) To employ such technical and other personnel as may be necessary for the performance of its powers and duties.

39151. No new motor vehicle required pursuant to this part to meet the omission standards in Article 2 (commencing with Section 39100) of this chapter or the standards set pursuant to Section 39052.5 or 39052.6, or revised standards set pursuant to subdivision (k) of Section 39052, shall be sold and registered in this state unless the engine and transmission combination used in that vehicle has been approved by the board.

Commencing with 1972 model year motor vehicles, the board shall not approve any such engine and transmission combination which requires a gasoline having a research octane number greater than 91, when used in conjunction with a power train normally associated with that engine and transmission combination.

Vehicle manufacturers shall test engine and transmission combinations in vehicles which are representative of the types of vehicles in which that engine and transmission combination is used.

In approving new motor vehicles, the test procedures established by the board pursuant to Section 39052 shall be conducted with a gasoline having a research octane number not greater than 91.

39154. No new motor vehicle required pursuant to this part to meet the emission standards in Article 2 (commencing with Section 39100) of this chapter shall be sold and registered in this state if the vehicle manufacturer has in the previous year for which the board approved his vehicles failed to comply with the standards established in this part or with such regulations as the board may establish, unless the manufacturer thereof complies with such other conditions as the board may by regulation indicate.

The procedures for determining, and the facts constituting, compliance and failure of compliance shall be established by the board pursuant to subdivision (c) of Section 39051.

39155. Each new motor vehicle required pursuant to this part to meet the emission standards in Article 2 (commencing with Section 39100) of this chapter shall be in all material respects substantially the same in construction as the test engine and transmission combination which has been approved by the board in accordance with Section 39151, provided that changes with respect to new motor vehicles previously approved may be made if such changes do not increase emissions above those for which approval was granted and provided that such changes are made in accordance with procedures specified by the board pursuant to subdivision (k) of Section 39052.

Article 5. Used Motor Vehicle Device Accreditation

39175. The board shall have the powers and authority necessary to carry out the duties imposed on it by this article including, but not limited to, the following:

(a) To adopt rules and regulations in accordance with the provisions of the Administrative Procedure Act (commencing with Section 11370) of the Government Code, necessary for proper execution of the powers and duties granted to, and imposed upon the board by this article.

(b) To employ such technical and other personnel as may be necessary for the performance of its powers and duties.

(c) To determine and publish by January 1, 1969, tests and procedures for the accreditation of used car exhaust emission control and fuel system evaporative loss control devices.

(d) To accredit motor vehicle pollution control devices following tests by the board or by a board-designated laboratory in which the board finds that the device operates within the standards set in Article 2 (commencing with Section 39100) of this chapter or that the device effectively controls harmful pollutants not specifically mentioned in Article 2 (commencing with Section 39100) of this chapter, or that the device effectively controls emissions from a part of the vehicle not specifically mentioned in Article 2 (commencing with Section 39100) of this chapter. Any device accredited shall be technologically feasible.

(e) To determine and publish the criteria for accreditation.

39176. Whenever an exhaust emission control device is accredited pursuant to the provisions of this article and is available for installation as determined by the board, every 1955 through 1965 year model vehicle shall be equipped with an accredited device to control the emission of pollutants from the exhaust in accordance with the requirements, exemptions and schedule of installation provided in Article 3 (commencing with Section 39125) of this chapter.

39177. The board may exempt classifications of motor vehicles for which accredited devices are not available, and motor vehicles whose emissions are found by appropriate tests to meet state standards without additional equipment, and motor-driven cycles, implements of husbandry, and vehicles which qualify for special license plates under Section 5004 of the Vehicle Code.

39178. The board may revoke, suspend or restrict an accreditation of a previously accredited device or an exemption previously granted upon a determination by the board that the device no longer operates within the standards set by the board or no longer meets the criteria adopted pursuant to subdivision (e) of Section 39175 or no longer should be exempted. Provided that once any motor vehicle is equipped with an accredited device it shall not thereafter be deemed in violation of this chapter or Section 27156 of the Vehicle Code because the accreditation of such device is subsequently revoked, suspended or restricted, and replacement parts for such device may continue to be supplied and used for such vehicle, unless such revocation, suspension or restriction is based upon a finding that the accredited device has been found to be defective, in which event such devices must be brought into compliance with this chapter within 30 days after such finding.

39179. Proceedings under this article with respect to the denial of applications for accreditation, the granting of exemptions, or for the revocation, suspension, or restriction of accreditation previously granted by the board shall be conducted in accordance with the provisions of Chapter 5 (commencing with Section 11500), Part 1, Division 3, Title 2 of the Government Code, and the board shall have all the powers granted therein.

39180. In establishing tests and procedures the board shall adopt standards including, but not limited to the following:

(a) An accredited exhaust emission control device shall not cost more than sixty-five dollars ($65), including the cost of installation.

(b) An accredited exhaust emission control device shall not require maintenance more than once each 12,000 miles, and such maintenance shall not cost more than fifteen dollars ($15), including cost of parts and labor.

(c) An accredited exhaust control device shall equal or exceed the performance criteria established by the board for devices for new motor vehicles or, in the alternative, have an expected useful life of at least 50,000 miles of operation.

(d) Standards for an accredited fuel system evaporative loss control device shall take into consideration the cost of the device and its installation, its durability, the ease and facility of determining whether the device, when installed on a motor vehicle is properly functioning, and any other factors which, in the opinion of the board, render such a device suitable or unsuitable for the control of motor vehicle air pollution or for the health, safety, and welfare of the public.

(e) An accredited fuel system evaporative loss control device shall equal or exceed the performance criteria established by the board for such new devices required on new motor vehicles, or in the alternative, must have an expected useful life of at least 50,000 miles of operation.

39180.1. Whenever the board accredits a fuel system evaporative loss control device for which standards have been set by this chapter, it shall submit a report of its findings and its recommendations for installation on used vehicles to the Legislature within 10 days, if it is then in session, or if not in session not later than January 15, of the next general session Such report shall contain a report on the cost of such device, including the cost of installation and a review of its potential performance, including required maintenance and the cost of parts and labor.

39180.22. No accredited fuel system evaporative loss control device for installation on used motor vehicles, nor any other accredited device not mentioned in Section 39129 shall be required to be installed on any used motor vehicles until approved by statute enacted by the Legislature.

39181. The board may issue permits for the testing of experimental motor pollution control devices installed in used motor vehicles, or for the testing of experimental or prototype motor vehicles which appear to have very low emission characteristics.

39182. Any manufacturer of a device required by this article shall, as a condition of accreditation of such device by the board, agree that so long as only one such device is accredited by the board such manufacturer shall either: (1) agree to enter into such cross-licensing or other agreements as the board determines are necessary to insure adequate competition among manufacturers of such devices to protect the public interest; or (2) agree as a condition to such accreditation that if only one such device from one manufacturer is made available for sale to the public, the board shall, taking into consideration the cost of manufacturing the device and the manufacturer's suggested retail price, and in order to protect the public interest, determine the fair and reasonable retail price of such device and may require as a condition to continued accreditation of such device, that the retail price of such device, including installation, not exceed such price as determined by the board. In either event the retail price so determined by the board for a device required by Section 39176 shall not exceed sixty-five dollars ($65) per vehicle.

39183. ,Whenever the board accredits a device for the control of emissions of pollutants from a particular source of emissions from motor vehicles for which standards have been set by this chapter and the board, it shall so notify the Department of Motor Vehicles.

39184. No person shall sell, display, advertise, or represent as an accredited device any device which, in fact, is not an accredited device. No person shall install or sell for installation upon any used motor vehicle any motor vehicle pollution control device which has not been accredited by the board.

Article 6. Variances

39190. The Governor with the advice and consent of the Senate shall appoint a hearing board to consist of three members, none of whom is employed by the board or the state. Two members shall be registered professional engineers knowledgeable in motor vehicle emission control. One member shall have been admitted to practice law in this state.

39191. The Governor shall appoint one member of the hearing board for a term of one year, one for a term of two years and one for a term of three years. Thereafter the terms of members of the hearing board shall be three years.

39192. The hearing board at the request of any person may hold a hearing to determine under what conditions and to what extent a variance from the emission standards for new or used cars established by Article 2 (commencing with Section 39100) of this chapter or by rules, regulations, or orders of the board is necessary and will be permitted. All such hearings shall be open to the public and shall be held at a place which the board determines to be convenient to the public in the area most affected by the motor vehicle air pollution problem.

39193. The board may provide, by regulation, a schedule of fees which will yield a sum not exceeding the estimated cost of the administration of this article, for the filing of applications for variances or to revoke or modify variances. All applicants shall pay the fees required by such regulations.

39194. The hearing board shall serve a notice of the time and place of a hearing to grant a variance upon the chairman and the executive officer of the board and upon the applicant, if any, not less than 10 days prior to such hearing.

39195. If the hearing board finds that because of conditions beyond control, compliance with the standards

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in Article 2 (commencing with Section 39100) of this chapter or with any rule, regulation, or order of the board will result in an arbitrary and unreasonable taking of property or in a serious and demonstrable economic hardship without a sufficient corresponding benefit or advantage to the people in the reduction of air pollution, it shall prescribe other and different standards not more onerous applicable to named classes of industries or persons. Tests and procedures for determining compliance with the standards established by the hearing board shall be the same as those tests and procedures established by the State Air Resources Board.

In establishing other and different standards the hearing board shall not prescribe standards less onerous than any applicable federal standards. Any federal standard enacted or implemented during the period for which a variance granting a less onerous standard is running shall immediately supersede the standard established by the hearing board.

39196. Notwithstanding the provisions of Section 39195, the hearing board shall grant variances to manufacturers of new motor vehicles only on a showing that the vehicle manufacturer is making all reasonable efforts to comply with the standards as soon as possible.

39196.5. The hearing board may revoke or modify by written order, after a public hearing held upon not less than 10 days' written notice, any order permitting a variance.

39197. The hearing board shall serve notice of the time and place of a hearing to revoke or modify any order permitting a variance not less than 10 days prior to such hearing upon the director and the executive officer of the board, upon all persons who will be subjected to greater restrictions if such order is revoked or modified as proposed and upon all other persons interested or likely to be affected who have filed with the hearing board or board a written request for such notification.

39197.5. The hearing board shall serve a notice of the time and place of a hearing to grant a variance or to revoke or modify an order permitting a variance either by personal service or by first-class mail, postage prepaid. If either the identity or address of any person entitled to notice is unknown, the hearing board shall serve such person by publication of notice once in a newspaper of general circulation published within the State of California.

39198. The hearing board in making any order permitting a variance may specify the time during which such order will be effective, in no event to exceed one year.

39199. The hearing board in administering the provisions of this article may conduct investigations and hearings pursuant to Article 2 (commencing with Section 11180), Chapter 2, Part 1, Division 3, Title 2 of the Government Code.

39200. After each hearing for a variance under proceedings held pursuant to this article, the hearing board shall make written findings of fact based upon the evidence and shall render a written decision. Such findings and written decision shall contain a detailed description of all testing data and testing procedures used in connection with the evidence submitted to the hearing board. Each written decision, accompanied by the findings, shall be transmitted to the Legislature forthwith. Nothing in this section shall require or authorize the disclosure of any trade secret privileged under Section 1060 of the Evidence Code, or of any information not a part of the public record the disclosure of which is prohibited by Section 11183 of the Government Code.

39201. The hearing board created by this article shall not exercise or undertake any duty, power, responsibility or jurisdiction vested in the hearing board by this article unless, and until, the State Air Resources Board determines that the Secretary of Health, Education and Welfare will not waive application to California of Section 208 of the National Emission Standards Act. In the event of such a determination by the State Air Resources Board then and then only shall Sections 39192 to 39200, inclusive, of this article become operative.

CHAPTER 5. LOW-EMISSION MOTOR VEHICLES

39250. The Legislature finds and declares that emission of pollutants from motor vehicles is a major contributor to air pollution within the State of California and, therefore, declares its policy to encourage the development and testing of various types of low-emission motor vehicles, which would contribute substantially to achieve a pure and healthy atmosphere for the people of this state.

39251. As used in this chapter "low-emission motor vehicle" shall mean a self-propelling vehicle which does not have exhaust emissions of more than .5 grams per mile of hydrocarbons, 11 grams per mile of carbon monoxide, and .75 grams per miles of oxides of nitrogen.

39252. Low-emission motor vehicles shall be submitted to the board for testing to determine if such vehicle meets the standards set forth in Section 39251.

39253. After determining that the low-emission motor vehicle meets the standards prescribed in Section 39251, the Department of General Services in consultation with the board shall determine if the low-emission motor vehicle meets all of the following requirements:

(a) Such vehicle can be manufactured in sufficient numbers for the purpose of proper evaluation.

(b) Such vehicle meets the performance needs for state vehicles.

(c) The cost of such vehicle does not exceed by more than 100 percent the average cost of state passenger vehicles purchased in the fiscal year.

(d) If such vehicle is purchased by the state there would be a sufficient number of servicing and maintenance outlets.

(e) The average servicing and maintenance costs for a low-emission vehicle are comparable to the average servicing and maintenance costs for all other state passenger vehicles, but in no event shall the average servicing and maintenance costs for the low-emission vehicle exceed the average costs of servicing and maintaining all other state passenger vehicles by more than 50 percent.

39254. If a low-emission motor vehicle meets the requirements of this chapter, the state shall, if funds are appropriated for the purpose of purchasing low-emission motor vehicles, purchase, beginning with the next fiscal year, as many of such low-emission motor vehicles as the Department of General Services determines are reasonable to meet state needs and which are in accordance with manufacturing capability, performance, cost, servicing, and maintenance of such vehicles. If a sufficient number of low-emission vehicles are available, the percentage of all such vehicles to be purchased in that year shall not be less than 25 percent of all motor vehicles purchased by the state in the preceding fiscal year.

39255. The provisions of this chapter shall not apply to the following vehicles:

(a) Patrol cars of the Department of the California Highway Patrol.

(b) Any motor vehicle classified as a special-purpose vehicle by the Department of General Services..

CHAPTER 6. ENFORCEMENT

39260. Any person who intentionally or negligently violates any order of abatement issued by any type of air pollution control district pursuant to Section 24260.5, 24354.15, or 39391 or by the State Air Resources Board pursuant to this part, shall be liable for a civil penalty not to exceed six thousand dollars ($6,000) for each day in which such violation occurs.

39261. Any person who intentionally or negligently violates Section 24242, 24243, or 39430, or any rule or regulation of a county air pollution control district or a regional air pollution control district or the State Air Resources Board issued pursuant to this part, prohibiting or limiting the discharge of air contaminants into the air, shall be liable for a civil penalty not to exceed five hundred dollars ($500) for each day in which such violation occurs.

39262. The civil penalties prescribed by Sections 39260 and 39261 shall be assessed and recovered in a civil action brought in the name of the people of the State of California by the Attorney General, by any district attorney, or by the attorney for any type of air pollution control district in which the violation occurs in any court of competent jurisdiction. In determining such amount, including but not limited to, the extent of harm caused by the violation, the nature and persistence of the violation, the length of time over which the violation occurs, and corrective action, if any, taken by the defendant.

An action brought pursuant to this section to recover such civil penalties shall take special precedence over all civil matters on the calendar of the court except those matters to which equal precedence on the calendar is granted by law.

If such an action is brought by the Attorney General on behalf of any type of air pollution control district, one-half of the penalty collected shall be paid to the treasurer of the district on whose behalf judgment was entered, and one-half of the penalty collected shall be paid to the State Treasurer for deposit in the Air Pollution Control Fund. If such an action is brought by the Attorney General on behalf of the State Air Resources Board, the entire penalty collected shall be paid to the State Treasurer for deposit in the Air Pollution Control Fund. If such an action is brought by a district attorney or by an attorney for any type of air pollution control district, the entire amount of the penalty collected shall be paid to the treasurer of the district on whose behalf judgment was entered.

39263. As used in Sections 39260 and 39261, "person" also means any state or local governmental agency or public district, or any officer or employee thereof. No officer or employee of the state or any local governmental agency or public district shall, however, be responsible under the provisions of Section 39260 or 39261 for any acts done by such governmental agency, or public district, in the performance of its functions or by such officers or employees in the performance of their duties. Any state or local governmental agency, or public district which violates Section 39260 or 39261 shall be subject to the civil penalty prescribed by Section 39260 or 39261.

39264. The provisions of this chapter shall not be applicable to vehicular sources as defined in Section 39007. (Amended August 12, 1970)

CHAPTER 7. COORDINATED BASINWIDE AIR POLLUTION CONTROL PLANS

39270. In each county, other than a county lying within the boundaries of the Bay Area Air Pollution Control District, which is entirely within one air basin but which is not a county air pollution control district which is functioning and exercising its powers nor a part of a regional air pollution control district, there shall, notwithstanding any other provision of law and without the adoption of any resolution by the board of supervisors thereof, be an air pollution control district of the kind provided for by, and which shall be subject to, administer, and enforce, the provisions of Chapter 2 (commencing with Section 24198) of Division 20 of this code.

39271. In each county, other than a county lying within the boundaries of the Bay Area Air Pollution Control District, which lies within more than one air basin, each portion of the county which lies within one air basin but which portion is not within a county air pollution control district which is functioning and exercising its powers nor a part of a regional air pollution control district, shall, notwithstanding any other provision of law and without the adoption of any resolution by the board of supervisors thereof, be an air pollution control district of the kind provided for by, and which shall be subject to, administer, and enforce, the provisions of Chapter 2 (commencing with Section 24198) of Division 20 of this code, whose boundaries shall be coterminous with the boundaries of the portion of the county lying within a single air basin.

39272. If on April 1, 1971, there is not in each air basin a single regional district with boundaries coterminous with those of air basin, the local and regional authorities in each such air basin shall, on or before July 1, 1971, establish a Basinwide Air Pollution Control Coordinating Council composed of the air pollution control officer of each air pollution control district all or a part of which lies within the basin, to represent all local and regional authorities in the air basin to the board.

39273. Each basinwide regional district and each council established pursuant to Section 39272 shall establish a coordinated basinwide air pollution control plan and such district or council shall submit such plan to the board by no later than January 1, 1972. *If there are federally recognized regional planning agencies within the air basin, the plan, or any proposed amendment thereto, shall first be submitted*

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to such agencies for their review and comments. The plan or the proposed amendment shall be submitted with such comments to the board. Such plan shall include emission standards, and enforcement procedures which will within a reasonable time achieve or exceed the air quality standards established by the board for that air basin. Such plan may be reviewed continuously or periodically by the basinwide regional district or council and shall be reviewed thereby at least once every two years. Such plan shall be reviewed by the basinwide regional district or council upon the request of any air pollution control district of any type or of the board. Each revised plan shall be submitted to the board.

39724. If the board finds that any original or revised coordinated basinwide air pollution control plan established and submitted pursuant to Section 39273 will not achieve the air quality standards established for that basin, or if no timely original or revised plan has been submitted, the board shall establish a coordinated basinwide air pollution control plan which would achieve the air quality standards in effect for that basin. Such plan shall include emission standards and rules and regulations, which shall be enforced by the basinwide regional air pollution control district, or, if no basinwide regional district is functioning in that basin, by all local and regional authorities within that basin. If the board finds that reasonable action to enforce any plan, whether established by a basinwide regional air pollution district or council or by the board, has not been taken, the board may take any appropriate legal action to enforce any such plan, including the emission standards and enforcement procedures therein. The board shall also have the authority to take in any county air pollution control district any action a functioning district is authorized to take pursuant to Chapter 2 (commencing with Section 24198) of Division 20, and to take in the Bay Area Air Pollution Control District any action such district is authorized to take pursuant to Chapter 2.5 (commencing with Section 24345) of Division 20, and to take in any regional air pollution control district any action such a district is authorized to take pursuant to Chapter 3 (commencing with Section 39350) of Part 2 of Division 26, to enforce any plan, including the emission standards and enforcement procedures therein.

39275. On or before January 1, 1972, each county district all or a part of which lies within an air basin shall submit to the board a program to implement the air pollution control plan of the basin within that county district. If the board finds that the program will not achieve the air quality standards established for the basin, or if no program is submitted within the time specified in this section, the board may exercise the powers of the county air pollution control district within the basin.

CHAPTER 10. BURNING

Article 1. Definitions and General Provisions

39295. "Combustible or flammable solid waste," as used in this chapter, means any garbage, rubbish, trash, rags, paper, boxes, crates, excelsior, ashes, offal, carcass of a dead animal, or any other combustible or flammable refuse matter which is in a solid form.

39295.1. "Flue," as used in this chapter, means any duct or passage for air, gases, or the like, such as a stack or chimney.

39295.2. "Open outdoor fire," as used in this chapter means any combustion of solid waste outdoors in the open, not in any enclosure, where the products of combustion are not directed through a flue.

39295.3. "Person," as used in this chapter, means any person, firm, corporation, association, or public agency, including, but not limited to, any city, county, district, or the state.

39295.4. "Solid Waste dump," as used in this chapter, means any accumulation for the purpose of disposal of any solid waste.

39295.5. "Orchard or citrus grove heater," as used in this chapter, means any article, machine, equipment or other contrivance, burning any type of fuel or material capable of emitting air contaminants, used or capable of being used for the purpose of giving protection from frost damage.

39295.6. "Agricultural burning," as used in this chapter means open outdoor fires used in agricultural operations in the growing of crops or raising of fowls or animals, forest management *or range improvement.*

39295.7. The provisions of this chapter shall not supersede any rule or regulation of any air pollution control district, which rule or regulation has been in effect for five or more years prior to the effective date of this chapter.

Article 2. Prohibitions

39296. No person shall, after December 31, 1971, use open fires for the purpose of disposal of petroleum wastes, demolition, debris, tires, tar, trees, wood waste, or other combustible or flammable solid *or liquid* waste; or for metal salvage or burning of automobile bodies.

39296.1. Any violation of the provisions of this article is a misdemeanor *punishable by imprisonment in the county jail not exceeding six months, or by fine not exceeding five hundred dollars ($500), or both, and the cost of putting out the fire.* Every day during any *portion* of which such violation occurs constitutes a separate offense.

39296.2. Any violation of any provision of this chapter or of any order, rule, or regulation of the board may be enjoined in a civil action brought in the name of the people of the State of California, except that the plaintiff shall not be required to allege facts necessary to show or tending to show lack of adequate remedy at law or to show or tending to show irreparable damage or loss.

Article 3. Exceptions

39297. Nothing in this chapter shall be construed as limiting the authority granted under other provisions of law:

(a) To any public officer to set or permit a fire when such fire is, in his opinion, necessary for any of the following purposes:

(1) For the purpose of the prevention of a fire hazard which cannot be abated by any other means, or

(2) The instruction of public employees in the methods of fighting fire,

(3) Set pursuant to permit on property used for industrial purposes for the purpose of instruction of employees

in methods of fighting fire.

(b) To set or cause to be set backfires necessary to save life or valuable property pursuant to Section 4426 of the Public Resources Code.

(c) To abate fires pursuant to Chapter 2 (commencing with Section 13025) of Part 1 of Division 12.

39297.1. Nothing in this chapter shall be construed as prohibiting agricultural burning authorized pursuant to Article 4 (commencing with Section *39298*) of this chapter.

39297.2. Nothing in this chapter shall be construed as prohibiting burning for the disposal of combustible or flammable solid waste of a single- or two-family dwelling on its premises.

39297.3. Nothing in this chapter shall be construed to prohibit burning for right-of-way clearing by a public entity or utility or for levee and ditch maintenance.

39297.4. The board shall permit a city, city and county, or county to use open outdoor fires, for a limited time only, in its operation of a solid waste dump, upon the finding that because of sparse population in the geographical area and economic and technical difficulties, the solid waste dump should be so operated.

Article 4. Agricultural Burning

39298. The board shall cause to be determined and designated from meteorological data the periods when agricultural burning shall not be permitted within each basin on the basis of the implementation plan or plans, as the case may be, for such basin adopted pursuant to Sections *39298.8 and 39298.9.*

39298.1. (a) No person knowingly shall set or permit agricultural burning unless he has a valid permit from the agency designated by the board to issue such permits in the area where the agricultural burning is to take place. A violation of the provisions of this subdivision is a misdemeanor *punishable by imprisonment in the county jail not exceeding six months, or by fine not exceeding five hundred dollars ($500), or both, and the cost of putting out the fire.* Every day during any portion of which such violation occurs constitutes a separate offense.

(b) The board shall designate public fire protection agencies or other equivalent agencies to issue permits under subdivision (a), and shall adopt rules and regulations to provide a procedure for the issuance of the permits. Each agency so designated by the board shall issue permits subject to the rules and regulations of the board.

(c) No permit shall be valid for any day during a period in which agricultural burning is prohibited by the board pursuant to Section *39298.*

(d) Each permit issued pursuant to this section shall bear a statement of warning containing the following words or words of like or similar import:

"This permit is valid only on those days which are not prohibited by the *State* Air Resources Board pursuant to Section *39298* of the Health and Safety Code."

39298.2. The board shall promulgate guidelines for the regulation and control of agricultural burning for each of the basins established by the board. Such guidelines shall be promulgated no later than six months from the effective date of this chapter for the following basins: Sacramento Valley, San Joaquin Valley, Bay Area, South Coast, *North Central Coast*, and South Central Coast.

39298.3. The guidelines promulgated by the board shall be based on meteorological data, the nature and volume of materials to be burned, and the probable effect of such burning on *the ambient* air quality within the air basins affected.

39298.4. In adopting such guidelines, the board shall consider their economic and technical feasibility, including their probable effect on agricultural production in the basin affected.

39298.5. The board shall continuously review the guidelines promulgated under this article, and may modify, repeal, or alter such guidelines if scientific and technological data indicates that such changes are warranted. Before adopting any such changes, the board shall hold a public hearing and shall consider the criteria set forth in Section *39298.3.*

39298.6. The board shall, by January 15, 1971, submit a report to the Legislature on its progress, including their proposed guidelines for the basins designated in Section *39298.3*, plans for promulgating standards in the remaining air basins in California, and a future proposal for the control of forest and open-range burning.

39298.7. The board shall adopt and publish a list of orchard and citrus heaters which it finds produce no more than one gram per minute of unconsumed solid carbonaceous material. No new orchard or citrus heater produced or manufactured shall be sold for use against frost damage after January 1, 1971, unless it has been approved by the board. No person shall use any orchard or citrus heater after January 1, 1975, unless it has been approved by the board or does not produce more than one gram per minute of unconsumed solid carbonaceous material. Any violation of this section is a misdemeanor *punishable by imprisonment in the county jail not exceeding six months, or by fine not exceeding five hundred dollars ($500), or both, and the cost of putting out the fire.* Every day during any portion of which such violation occurs constitutes a separate offense.

Notwithstanding Section 39057, local or regional authorities may adopt ordinances, which may become operative at any time on or after January 1, 1973, prohibiting the use of any orchard or citrus heater which has not been approved by the board.

39298.8. Within six months after the guidelines for a basin are adopted by the board, each local and regional authority within each basin shall adopt an implementation plan consistent with the guidelines of the board. Local authorities may within each basin jointly adopt an implementation plan for their combined areas. Each plan shall include emission standards and enforcement procedures based on such guidelines. In adopting such plan, each local and regional authority shall consider the economic cost and technical feasibility *of* disposing of agricultural wastes.

The plan shall be adopted by ordinance, and any violation of the provisions of the plan is a misdemeanor *punishable by imprisonment in the county jail not exceeding six months, or by fine not exceeding five hundred dollars ($500), or both, and the cost of putting out the fire.* Every day during any *portion* of which such violation occurs constitutes a separate offense.

39298.9. Each implementation plan shall be submitted to the board for approval. After *public hearings,* the board

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shall either approve, modify, or reject the plan submitted to it. The board shall approve the plan if it determines the plan is reasonably calculated to achieve air quality standards applicable to the basin. If the plan is rejected, or if no timely plan is submitted, or if the plan is economically or technically unfeasible, the board shall have all the powers of any local and regional authority within the basin to adopt an alternative plan for the local or regional authority. The board shall not adopt any alternative plan without first holding public hearings within the basin affected.

39299. No person shall knowingly set or permit agricultural burning on days within a period prohibited by the board pursuant to Section *39298.*

A violation of this section is a misdemeanor *punishable by imprisonment in the county jail not exceeding six months, or by fine not exceeding five hundred dollars ($500), or both, and the cost of putting out the fire.* Every day during any portion of which such violation occurs constitutes a separate offense.

39299.1. The board shall conduct studies of the alternative methods of disposing of agricultural waste other than by burning.

39299.2. An air pollution control district which is functioning and exercising its powers may by permit authorize agricultural burning on days designated by the board as nonburning days when *denial of such permit would threaten imminent and substantial economic loss.*

The board shall require air pollution control districts to transmit regular reports of permits issued authorizing agricultural burning on nonburning days. The report shall include the number of such permits issued, the date of issuance of each permit, the person or persons to whom the permit was issued, and any other information requested by the board.

39299.3. It is the intent of the Legislature, by the enactment of this article, that agricultural burning be reasonably regulated, and not be prohibited, by the board. The board shall take into consideration, in adopting rules and regulations for purposes of this article, various factors, including, but not limited to, the population in an area, the geographical characteristics, the meteorological conditions, the economic and technical impact of such rules and regulations, and the importance of a viable agriculture economy in the state.

Sec. 10. Section 2814 of the Vehicle Code is amended to read:

2814. Every driver of a passenger vehicle shall stop and submit the vehicle to an inspection of the mechanical condition and equipment of the vehicle at any location where members of the California Highway Patrol are conducting tests and inspections of passenger vehicles and when signs are displayed requiring such stop.

The Commissioner of the California Highway Patrol may make and enforce regulations with respect to the issuance of stickers or other devices to be displayed upon passenger vehicles as evidence that the vehicles have been inspected and have been found to be in safe mechanical condition and equipped as required by this code and equipped with certified motor vehicle pollution control devices as required by Chapter 4 (commencing with Section 39080) of Part 1 of Division 26 of the Health and Safety Code which are correctly installed and in operating condition. Any sticker so issued shall be placed on the windshield within a five-inch square in the extreme lower left corner thereof with respect to the driver's position.

If, upon such an inspection of a passenger vehicle, it is found to be in unsafe mechanical condition or not equipped as required by this code and the provisions of Chapter 4 (commencing with Section 39080) of Part 1 of Division 26 of the Health and Safety Code, the provisions of Article 2 (commencing with Section 40150) of Chapter 1 of Division 17 of this code shall apply.

Sec. 11. Section 4000 of the Vehicle Code is amended to read:

4000. (a) No person shall drive, move, or leave standing any motor vehicle, trailer, semitrailer, pole or pipe dolly, logging dolly, or auxiliary dolly upon a highway unless it is registered and the appropriate fees have been paid under this code.

No person shall drive, move, or leave standing any motor vehicle upon a highway which has been registered in violation of Chapter 4 (commencing with Section 39080) of Part 1 of Division 26 of the Health and Safety Code.

(b) The provisions of this section shall not apply, following payment of fees due for registration, during such time that registration and transfer is being withheld by the Department of Motor Vehicles pending the investigation of any use tax due under the provisions of the Revenue and Taxation Code.

(c) When a vehicle is towed by a tow car on order of a sheriff, marshal, or other official acting pursuant to a court order or on order of a peace officer acting pursuant to the provisions of Chapter 10 (commencing with Section 22650) of Division 11, the provisions of subdivision (a) of this section shall not apply.

Sec. 12. Section 4000.1 of the Vehicle Code is amended to read:

4000.1. (a) On and after December 1, 1965, the department shall require upon transfer of ownership and registration of any motor vehicle subject to Chapter 4 (commencing with Section 39080) of Part 1 of Division 26 of the Health and Safety Code, a valid certificate of compliance from a licensed motor vehicle pollution control device installation and inspection station indicating that such vehicle is properly equipped with a certified device or devices which are in proper operating condition and which are in compliance with the provisions of Chapter 4 (commencing with Section 39080) of Part 1 of Division 26 of the Health and Safety Code.

(b) The State Air Resources Board established under Chapter 4 (commencing with Section 39080) of Part 1 of Division 26 of the Health and Safety Code may exempt designated classifications of motor vehicles from the provisions of subdivision (a) as they deem necessary, and shall notify the department of such action; provided, however, that no exemption shall be granted to those vehicles subject to the provisions of subdivision (g) of Section 39129 of the Health and Safety Code, except as provided therein.

Sec. 13. Section 4750 of the Vehicle Code is amended to read:

4750. The department shall refuse registration or renewal or transfer of registration upon any of the following grounds:

(a) That the application contains any false or fraudulent statement.

(b) That the required fee has not been paid.

(c) That the registration or renewal or transfer of registration is prohibited by the requirements of Chapter 4 (commencing with Section 39080) of Part 1 of Division 26 of the Health and Safety Code.

Sec. 14. Section 24007 of the Vehicle Code is amended to read:

24007. (a) No dealer or person holding a retail seller's permit shall sell a new or used motor vehicle which is not in compliance with the provisions of this code and department regulations adopted pursuant to this code unless the vehicle is sold to another dealer or for the purpose of being wrecked or dismantled or is sold exclusively for off-highway use.

(b) No dealer shall sell a new or used motor vehicle subject to the provisions of Chapter 4 (commencing with Section 39080) of Part 1 of Division 26 of the Health and Safety Code which is not in compliance with the provisions of Chapter 4 (commencing with Section 39080) of Part 1 of Division 26 of the Health and Safety Code and the rules and regulations of the State Air Resources Board, unless the vehicle is sold to another dealer or for the purpose of being wrecked or dismantled. The dealer shall, with each application for transfer of registration of every 1955 or later year model motor vehicle subject to Chapter 4 (commencing with Section 39080) of Part 1 of Division 26 of the Health and Safety Code, transmit to the Department of Motor Vehicles a valid certificate of compliance from a licensed motor vehicle pollution control device installation and inspection station indicating that such vehicle is properly equipped with a certified device or devices which are in proper operating condition and which are in compliance with the provisions of Chapter 4 (commencing with Section 39080) of Part 1 of Division 26 of the Health and Safety Code.

Sec. 15. Section 27153.5 is added to the Vehicle Code, to read:

27153.5 (a) No motor vehicle first sold or registered as a new motor vehicle on or after January 1, 1971, shall discharge into the atmosphere at elevation of less than 3,000 feet any air contaminant for a period of more than 10 seconds which is:

(1) As dark or darker in shade as that designated as No. 1 on the Ringelmann Chart, as published by the United States Bureau of Mines, or

(2) Of such opacity as to obscure an observer's view to a degree equal to or greater than does smoke described in paragraph (1) of this subdivision.

(b) No motor vehicle first sold or registered prior to January 1, 1971, shall discharge into the atmosphere at elevation of less than 3,000 feet any air contaminant for a period of more than 10 seconds which is:

(1) As dark or darker in shade than that designated as No. 2 on the Ringelmann Chart, as published by the United States Bureau of Mines, or

(2) Of such opacity as to obscure an observer's view to a degree equal to or greater than does smoke described in paragraph (1) of this subdivision.

Sec. 16. Section 27156 of the Vehicle Code is amended to read:

27156. No person shall operate or leave standing upon any highway any motor vehicle which is required to be equipped with a certified motor vehicle pollution control device under Chapter 4 (commencing with Section 39080) of Part 1 of Division 26 of the Health and Safety Code unless the motor vehicle is equipped with a certified motor vehicle pollution control device which is correctly installed and in operating condition. No person shall disconnect, modify, or alter any such device in a manner which will decrease its efficiency of effectiveness in the control of air pollution.

Sec. 17. Section 28500 of the Vehicle Code is amended to read:

28500. As used in this chapter:

(a) "Motor vehicle pollution control device" and "certified device" shall be construed as defined in Sections 39093 and 39094 of the Health and Safety Code.

(b) "Station" means a motor vehicle pollution control device installation and inspection station.

(c) "Licensed station" means a station licensed by the department pursuant to this chapter.

(d) "Licensed installer" means a person licensed by the department for installing, repairing, inspecting, or recharging motor vehicle pollution control devices in licensed stations.

Sec. 18. Section 28502 of the Vehicle Code is amended to read:

28502. (a) The department shall license stations and shall designate, furnish instructions to develop regulations for, and supervise licensed stations for installing, repairing, inspecting, or recharging motor vehicle pollution control devices in conformity with the provisions of Chapter 4 (commencing with Section 39080) of Part 1 of Division 26 of the Health and Safety Code and the rules and regulations of the department. The department shall establish standards for the qualifications, including training, of licensed installers as a condition to designating and licensing the station as a licensed station.

An owner of a fleet of three or more vehicles may be licensed by the department as a licensed station, provided such owner complies with the regulations of the department.

(b) The department shall license, furnish instruction to, develop regulations for, and supervise licensed installers as a condition for installing, repairing, inspecting, or recharging motor vehicle pollution control devices in licensed stations.

Sec. 19. Section 28506 of the Vehicle Code is amended to read:

28506. Any person may install a motor vehicle pollution control device; however, no person who is not a licensed installer shall install such a device for compensation. No such device shall be deemed to meet the requirements of this code or of Chapter 4 (commencing with Section 39080) of Part 1 of Division 26 of the Health and Safety Code and the rules and regulations of the State Air Resources Board unless it has been inspected by a licensed installer in a licensed station and a certificate of compliance has been issued by such licensed station.

Sec. 20. Section 28508 of the Vehicle Code is amended to read:

28508. Whenever a licensed installer in a licensed station, in conformity with the instructions of the depart-

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ment, installs, inspects, repairs, or recharges a motor vehicle polltuion control device, and determines that the device conforms with the requirements of Chapter 4 (commencing with Section 39080) of Part 1 of Division 26 of the Health and Safety Code, and the rules and regulations of the State Air Resources Board, a certificate of compliance shall be issued to the owner or driver of the vehicle. The department, for a fee of ten cents ($0.10), shall furnish to the licensed station the certificate of compliance to be issued.

The certificate of compliance shall contain provisions for the date of issuance; the make and registration number of the vehicle; the name of the owner of the vehicle; and the official designation of the station; and if the device involved was approved by the State Air Resources Board by the issuance of a certificate of approval requiring the obtaining of an annual certificate of compliance as authorized by Section 39131 of the Health and Safety Code, a statement that the certificate of compliance shall be valid only through the last day of the 12th month from the date of issuance.

The certificate of compliance shall be signed by a licensed installer who has installed, inspected, repaired, or recharged the motor vehicle pollution control device.

Part 2. Regional Air Pollution Control

CHAPTER 1. GENERAL PROVISIONS

39300. In this part, the terms and definitions contained in Article 1 (commencing with Section 39000), Chapter 1, Part 1, of this division shall apply.

39301. Within each basin established by the board, if the board of supervisors, or respective boards of supervisors, determine there is a need for such a district, or such districts to function, there may be established a regional district for the basin, regional district for a portion of the basin and a county or several county districts, or county districts. No county except a county which on the operative date of this section is within an air pollution control district which is functioning and exercising its powers, shall be required to be represented on a regional board, or have its own board, unless and until the board of supervisors, as authorized by Section 24205 adopt a resolution declaring that there is a need for an air pollution control district to function, or, as authorized by the part, a resolution is adopted by the board of supervisors of the county and by the board of supervisors of one or more other counties declaring there is need for a regional district to function in a common area, including all or any portion of such counties and certified copies of the resolutions are filed with the State Air Resources Board as provided in Section 39354. There shall not be more than one regional air pollution control district in any basin.

39302. The provisions of the Knox-Nisbet Act, Chapter 6.6 (commencing with Section 54773), Part 1, Division 5 of, and the District Reorganization Act of 1965, Division 1 (commencing with Section 56000), Title 6 of, the Government Code shall not be applicable to county districts or regional districts.

CHAPTER 2. DISTRICT AIR POLLUTION CONTROL BOARDS

39310. The board of supervisors of a county in which a district is not functioning and exercising the powers on the effective date of this part may, pursuant to Chapter 2 (commencing with Section 24198) of Division 20, cause an air pollution control district to commence to function and exercise its powers within the county to carry out the provisions of this division.

A county board of supervisors may establish jointly with other counties in the same basin a regional air pollution control district covering such portion of the county lying within the basin pursuant to this part for purposes of carrying out the provisions of this division.

39311. A county lying within more than one basin may establish jointly with other counties separate regional air pollution control districts and may establish a county air pollution control district for any portion of the county not within a regional district.

39312. If any district organized and functioning pursuant to Chapter 2 (commencing with Section 24198) of Division 20 is entirely within any area in which a regional district is created, upon the establishment of the regional district, such district is dissolved and the regional district succeeds to all of its property and obligations.

39313. Every county district board shall adopt rules and regulations to control the sources of air pollution within the district and shall comply with all the standards, rules and regulations set forth by the state board.

39314. (a) The county district board of any county air pollution control district in existence on the date on which the State Air Resources Board divides the state into basins pursuant to Section 39051, which, on or before such date, has adopted rules and regulations, shall file its rules and regulations with the state board within 30 days after such date.

(b) The county district board of any county air pollution control district in existence on such date which has not, on or before such date, adopted rules and regulations, shall file its rules and regulations with the state board within six months after such date.

(c) The county district board of any county air pollution control district created after such date shall file its rules and regulations with the state board within 12 months after creation of the district.

CHAPTER 3. REGIONAL AIR POLLUTION CONTROL DISTRICTS

Article 1. Creation of Regional Districts

39350. The boards of supervisors of two or more counties within a given basin may upon their own motion, acting separately or shall whenever a petition signed by not less than 10 percent of the qualified electors of each county is presented to the supervisors of that county, hold a public hearing to determine whether or not to become part of a regional air pollution control district.

39351. Prior to the public hearing, the board of supervisors shall give notice of the time and place of hearings by publication pursuant to Section 6061 of the Government Code not less than 15 days nor more than 45 days before such hearing.

APPENDIX F

CALIFORNIA BLOWBY DEVICE TEST PROCEDURE

This appendix includes only those selected portions of the "California Test Procedure and Criteria for Motor Vehicle Crankcase Emission Control" which are considered pertinent to this retrofit program study.

State of California
AIR RESOURCES BOARD

417 So. Hill St.
Suite 1085
Los Angeles, California 90013

CALIFORNIA TEST PROCEDURE AND CRITERIA FOR MOTOR VEHICLE CRANKCASE EMISSION CONTROL

SUMMARY

This is a suggested brief step by step summary of the procedure for certification of crankcase control devices.

For details please refer to the appropriate sections.

I. Application (Appendix V and VI)

It is most advisable that the applicant file the application before proceeding with any tests. If the application is not acceptable, this may save needless testing expense.

II. Testing Procedure (Section II and III)

If the staff finds the application satisfactory, then the test procedure may be started in the following sequence.

a) Bench flow test

To determine if the device may adversly effect the air fuel ratio, cold starting, hesitation, loss of power, stalling etc.

b) Backfire test

To determine if the device is safe.

c) Odor test.

To determine if the device will handle the 10th decile without outflow to the atmosphere.

d) 12,000 mile endurance test

If the device passes the first three tests, the applicant may start the 12,000 mile fleet and life test as outlined in the procedure.

The Staff or the Technical Advisory Group may also require any additional testing deemed necessary to arrive at a fair decision.

III. Financial Responsibility (Appendix II)

If a firm or individual cannot meet the financial responsibility section, the Board will withhold certification even if the device passes all the other requirements.

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State of California Section II

AIR RESOURCES BOARD

CALIFORNIA TEST PROCEDURE AND CRITERIA FOR MOTOR VEHICLE CRANKCASE EMISSION CONTROL

A. California Standards

The California standards for motor vehicle crankcase emissions are established by the State Department of Public Health under authority of Sections 426.1 and 426.5 of the Health and Safety Code, State of California. Present standards, adopted October 23, 1964, set forth in Section 30530 of the Health and Safety Code are as follows:

(a) The standard for motor vehicle crankcase emissions is: Hydrocarbons - 0.1 percent by weight of the supplied fuel.

(b) The standard refers to a composite sample representing the modes of engine operation described as follows:

Mode of Operation		Percent of total time
Idle		19
30 mph	16 in. Hg. manifold vacuum	37
30 mph	10 in. Hg. manifold vacuum	11
30 mph	2 in. Hg. manifold vacuum	8
Deceleration		25

(Blowby rate during deceleration is taken as zero.)

B. Criteria

In addition to meeting State standards, every device system controlling crankcase emissions from motor vehicles shall meet the following criteria according to California Administrative Code, Title 31, Chapter 3, Sub-chapter 1, Article 1, 2003:

(a) Be so designed as to have no adverse effect on engine operation or vehicle performance.

(b) Operate in a safe manner.

(c) Have sufficient durability so as to operate efficiently for at least 12,000 miles without maintenance.

(d) Operate in such a manner so as not to create excessive heat, noise, or odor beyond the standard characteristics of the motor vehicle without such device.

(e) The purchase or cost of installation of such device shall not constitute an undue cost burden to the motorist.

(f) Installation of such device shall not create or contribute to a noxious or toxic effect in the ambient air.

(g) The adequacy of methods of distribution, the financial responsibility of the applicant, and other factors affecting the economic interests of the motoring public, shall be evaluated and determined satisfactory to protect the motorist.

C. Other Requirements

1. It is recommended that the applicant arrange a conference with the engineering staff to ensure that test data is developed in a satisfactory manner. Before submitting an application and obtaining data in support of State Standards and Board criteria, it is further recommended that the applicant submit evidence to the engineering staff showing that his device system can comply with State standards.

2. Responsibility for submission of data rests with the applicant, and it is to be developed at his expense. Cross-check tests on prototypes may be performed at the Board's expense.

3. The Board's engineering staff will evaluate any information, data and representations submitted and may request additional testing by the applicant.

4. The Motor Vehicle Pollution Control Board will utilize a Technical Advisory Group of leading automotive experts to guide the Board and its staff in the evaluation of technical data and devices. The group will be comprised of technical representatives from groups such as: Automobile Service Industry Association, American Petroleum Institute, Western Oil and Gas Association, United States Public Health Service, Los Angeles County Air Pollution Control District and the Universities.

5. All applications received after the effective date of this procedure are subject to all conditions set forth herein.

6. The applicant shall specify in which displacement classes he seeks approval. Motor vehicles for which crankcase emission control devices will be certified are divided into the following classifications:

Class	Engine Displacement
a	Under 140 cubic inches
b	140-200 cubic inches
c	200-250 cubic inches
d	250-300 cubic inches
e	300-375 cubic inches
f	Over 375 cubic inches

D. Certification for NEW car factory installation

1. The applicant shall submit an application prepared according to instructions.

2. The applicant shall submit qualified test data showing compliance with the California standards for Crankcase Emissions, and criterion (d), with respect to odor. The latter entails submitting performance curves and data as follows:

   Acceptable evidence is device assembly flow data showing, for each applicable engine class or design, that no outflow to the atmosphere of crankcase emissions will occur at any of the test conditions, including 30 mph - 2"Hg manifold vacuum, for the tenth blowby deciles given in Table I. If it can be shown that an engine is so designed that blowby rates are inherently much lower than average, evidence that no outflow will occur at blowby rates five times the new engine rate will also be acceptable evidence that the odor criterion is met.

3. The applicant shall submit a written representation signed by a legal officer of the company stating that the control system as installed on new vehicles will comply with the Board's Criteria.

4. The applicant shall submit a prototype device system to the Board staff to allow verification of the test data.

5. The applicant shall submit a statement signed by a legal officer of the company stating that the device system will not be offered as replacement equipment except on the same new car upon which it was originally installed.

6. The applicant shall submit 18 glossy, labeled, black and white photographs showing the system on the automobile. (8" x 10")

7. For demonstration purposes the applicant shall submit a drawing approximately 30" x 40" showing the system installed on to the engine and illustrating flow through the system, or a mock up mounted on a board

E. Certification for USED car installation

1. The applicant shall submit an application prepared according to instructions. See appendix V & VI for sample application and instructions

2. The applicant shall submit qualified test data showing compliance with the California standards for Crankcase Emissions. This entails submitting performance curves and data relating to criteria (d) and (f).

3. The applicant shall submit qualified data and written representation signed by a legal officer of the company subject to evaluation by the engineering staff, showing that the system as designed and installed on used cars shall comply with the Board's criteria.

4. The applicant shall submit prototype devices to the engineering staff as requested for verification of test data.

5. The applicant shall submit 18 glossy, labeled, black and white photographs showing the system on the automobile. (8" x 10")

6. For demonstration purposes the applicant shall submit a drawing about 30" x 40" showing the system installed on the engine and illustrating flow through the system, or a mock up mounted on a board.

7. The applicant shall maintain accurate and complete records of all testing, and shall consult with the engineering staff before any deviations from the testing procedure are made.

F. Procedure for demonstrating compliance with State standards

1. Bench testing of Device System -

   In most cases flow characteristics of the device may be obtained by bench flow tests. Data from such tests shall be obtained by a qualified testing laboratory. The following data shall be presented to the staff.

   a. flow in CFM through the control valve, orifice, fan or control component corrected to 70°F for appropriate pressure differential, (e.g. 0-20" Hg. if connected to intake manifold).

   b. flow in CFM through all restrictive components as assembled in the system such as flame arrestor, hoses, check valves etc., corrected to 70°F for appropriate pressure differentials.

   c. flow in CFM through ventilated filler cap, if any, corrected to 70°F for 0-5" Hg. pressure differential.

   Sufficient points shall be measured to plot a smooth curve for the entire range of appropriate pressure differentials.

2. Test equipment required for flow tests:

   a. Calibrated rotameter, visicous flowmeter, venturi, totalizing flowmeter or other reliable flow test equipment.

   b. Flow temperature measurement means which is free of appreciable radiations errors.

   c. Controlled flow pump to develop the vacuum and flow necessary for testing of blowby system and compensate for pressure drop through the measuring equipment.

   d. Suitable manometer for measuring pressure differential between inlet and discharge point of blowby control system.

3. Blowby Measurements

Blowby flow should be measured on vehicles at idle; 30 mph, -16",10", 2" Hg. manifold vacuum. All openings from the crankcase except one shall be sealed for this work. For the purpose of measuring blowby, a calibrated and properly maintained rotameter, viscous flowmeter, iron case meter or other satisfactory air flow measuring equipment can be used. Again, the flow temperature at the measuring element, made in such a way as to minimize radiation errors, is to be measured. ACFM blowby flows should be corrected to, or measured near, 110°F. The SAE Crankcase Emission Control Test Code SAE J900 may be consulted for other details.

4. System Performance

Device system performance shall be calculated using the appropriate engine class values presented in Table I and the flow characteristics of the device when new, as measured above. Under each of the conditions, the average outflow at each condition (one-tenth the sum of the decile outflows) shall be weighted on the basis of % time given in the State standards (p.1). This total is the new device average outflow for a given device model size. Blowby at deceleration is taken as zero.

The outflows of the applicable model sizes for the class are to be weighted in proportion to California registration of applicable vehicles. This weighted outflow may then be compared with the "Standard" ACFM from the table, which is equivalent to compliance with the State standard of 0.1% supplied fuel maximum outflow, assuming a hydrocarbon concentration of 10,000 ppm as measured by a hexane-sensitized non-dispersive infrared analyzer. This is approximately equivalent to 15,000 ppm total hydrocarbons as hexane.

If the weighted outflow for the class is less than the "Standard" ACFM given, the device brings vehicles into compliance when it is new. In that case, the flow bench values for the test device assemblies after 12,000 miles of service as determined above are then compared with their values when new, to determine the overall average of percent deteriorations in capacity at each condition. These average percentages shall be applied to the previously used flows in their comparison with decile blowbys, yielding, by the same procedure, a 12,000 mile comparsion with the "Standard" ACFM outflow, to determine compliance at 12,000 miles.

G. Procedure for demonstrating compliance with criteria

Each criterion is listed with the appropriate procedure following. Those criteria which are related to service experience will be evaluated at 0 miles, and after 12,000 miles of driving. Those criteria which are not related to service life of the device will be tested at one time only.

Criterion (a) Be so designed as to have no adverse effect on engine operation or vehicle performance.

Procedure

The applicant shall submit data showing that the device:

1. Will not draw oil from the engine in amounts substantially greater than the unequipped engine. This to to be tested by incorporating in the system an oil trap in any hoses, pipes, or tubing carrying blowby, and by measuring oil consumption during fleet tests.

2. Will not cause crankcase explosions. A bench test such as the Scott Research Laboratories Backfire Test demonstrating the high improbability of flame propagation to the crankcase is required. Usually all devices must incorporate a mechanism for preventing flame propagation.

3. Will not cause excessive crankcase pressure or vacuum under the operating conditions specified in the State standards.

4. Will not cause excessive leaning of the air/fuel mixture such that part throttle surge, hard starting, tip-in stumble, spark knock, piston or valve burning, etc. become evident on those cars which are most subject to leaning. An increase in air/fuel ratio (leaning) of no more than 6% for any cylinders on first decile cars will be allowed. The procedure for calculating air/fuel ratio change is contained in Part J. Calculation for Air/Fuel Ratio Change.

5. Will not cause excessive enrichening of the air/fuel mixture such as fouled plugs, difficult hot starting and excessive gasoline consumption become evident on those cars most susceptible to enrichening. A decrease in air/fuel ratio (enrichening) of no more than 6% on tenth decile cars will be allowed. Calculations are covered in Part J.

6. Will not cause substantial maldistribution of air/fuel ratio among cylinders. Limits for change of air/fuel ratio for any cylinders are covered in 4 & 5 above. In general, the device must feed blowby gases into, at least, half the cylinders.

7. Will not create problems related to engine operation and reliability such as induction system icing, dust and water ingestion to crankcase or intake system, lubricant dilution with fuel, excessive oil sludging and crankcase deposit formation, vapor lock, etc.

8. Will be as "foolproof" as possible so as to minimize variations from proper installations of the device. This precludes the incorporation of external manual flow adjustments unless the applicant submits additional data showing that operating problems, as above, will not arise from incorrect adjustment.

9. Will allow clean ventilation air, at least comparable to that originally provided, to enter the crankcase.

Criterion (b) Operate in a safe manner.

Procedure

The applicant shall submit proof that the device or its installation will not affect fuel or electrical system so as to impair operation of the components or to increase the possibility of fire; and will not affect operation of any vacuum operated or vacuum-assisted mechanism, such as brakes, windshield wipers, defrosters, etc. In general, design and installation drawings, visual inspections and fleet testing will suffice as proof.

Criterion (c) Have sufficient durability so as to operate efficiently for at least 12,000 miles without maintenance.

Procedure

Testing for this criterion will be determined in conjunction with fleet testing as prescribed under Part H: Fleet and Life Testing . No device maintenance or adjustment will be allowed during the 12,000 miles. If any device or automotive component associated with the device or its installation fails, the Board's engineering staff will evaluate such failure to determine the cause and mode of failure, and the probability of such occurence in the vehicle population.

When the applicant claims service life of two or more years, additional test evidence beyond the 12,000 miles may be required by the Board to substantiate this claim.

The Board will consider any warranty on the device and device maintenance offered by the applicant as part performance of the service life requirement.

The applicant shall submit plans for ensuring the continued operation of the device. This would entail assurance of adequately equipped and trained dealer- service organizations, clear and concise installation instructions, field service representatives and provisions for servicing device complaints.

Criterion (d) Operate in such a manner so as not to create excessive heat, noise, or odor beyond the standard characteristic of the motor vehicle without such a device.

Procedure

1. Heat and noise will be evaluated by the Board's engineering staff, on a typical make and model vehicle. If these are objectionable, special tests may be required, as determined by the staff.

2. The staff will evaluate device system flow data for the applicable displacement classes which shows that no outflow of crankcase emissions to the atmosphere will occur at any of the test conditions including 30 mph - 2" Hg. intake manifold vacuum for tenth decile vehicles.

Criterion (e) The purchase or cost of installation of such device shall not constitute an undue cost burden to the motorist.

Procedure

The applicant shall submit cost estimates indicating approximate ultimate costs to the consumer. These estimates shall be submitted for factory installation, and for installation on used or new vehicles after leaving the factory, whichever is applicable.

Estimates should include such factors as cost of the complete system, cost of installation, replacement or renewal cost, maintenance cost and cost of fuel penalty, if any.

Information shall be submitted on the methods of proposed device distribution, installation, maintenance, and warranty.

The Board will evaluate information received from the applicant to determine whether the device will have sufficient geographical availabilit within the State of California, and may utilize financial advice from outside experts to determine if the costs indicated are accurate and reasonable, and to determine if they constitute "an undue cost burden to the motorist."

Criterion (f) Installation of such device shall not create or contribute to a noxious or toxic effect in the ambient air.

Procedure

Evidence must be submitted that the device or its installation will not cause an average air/fuel ratio decrease greater than 1% or increase greater than 4% for the applicable population. The procedure for calculating air/fuel ratio will be found under Part J: Calculations for Air/Fuel Ratio Change. Also see Criterion a-4, page 6.

Criterion (g) The adequacy of methods of distribution, the financial responsibility of the applicant, and other factors affecting the economic interests of the motoring public, shall be evaluated and determined satisfactory to protect the motorist.

Procedure

The applicant shall submit:(See Appendix II)

1. A current financial statement showing assets and liabilities, which shall be subject to audit, and other material as requested by the Executive Officer.
2. Letter of intent which will show method the company will employ to support their guarantee to the motorist. This should indicate what type of liability the company will assume for their product when installed on a motor vehicle and, if applicable, the insurance they have purchased to support that liability.

3. Letter of intent outlining details of the company or companies which will manufacture and/or distribute their device. This should include information as to continuing supply of replacement parts and field representation for servicing of complaints.

H. Fleet and Life Testing

1. Normal Service Testing

Tests will be run with devices installed on at least five vehicles in each of the engine displacement classes for which approval is sought. Where application is made for only one or two engine size classes a minimum of ten cars shall be tested. Cars selected for use shall represent the average car population of California, be about five to six years old, have 40,000 to 60,000 miles on them, and display average blowby rates no less than the 6th decile shown in Table I.

The automobiles in each engine size group will be tested for extended service up to 12,000 miles, with scheduled and approved maintenance, to show that the device or system will function properly and efficiently for that distance. Oil consumption records will be kept for the 12,000 mile period. Records will be kept and reported on the points where any malfunction occurs or maintenance is performed to keep the valves or systems in efficient operating condition. Device performance will be measured at zero and at 12,000 miles. The make of cars, service intervals, blowby rate and locality of mileage accumulation are subject to staff approval.

2. Accelerated Service Testing

Accelerated Service Testing may be utilized as an alternative to normal service testing. However, becuase of the short duration of such test, additional testing is required which simulates conditions encountered during normal service operation.

The accelerating testing car fleet requirements are identical to the normal service fleet except that, subject to staff approval, only 10 cars may be required. All record keeping, compliance testing and special testing must be accomplished by a qualified state testing laboratory.

The procedure for accelerated testing is as follows:

a. Mileage Accumulations - This is to be accomplished over a selected route which is comprised of city, residential and freeway driving, with a specified number of stops and idle periods. The average speed may not exceed 40 mph, excluding shut down and stops. All cars are to be driven four hours, shut off and allowed four hours of cooldown.

   Data to be obtained at 0 and 12,000 miles are: Compliance with standards, blowby, crankcase pressure and vacuum, valve flow, ventilation rate.

b. Taxi Tests - The staff may request that devices be installed on taxicabs as part of, or in addition to, the accelerated testing fleet. Taxicab service is quite similar to accelerated service testing and such testing provides reliable, representative data.

c. Idle test - In conjunction with fleet testing, the applicant must show additional proof that the device resists plugging or other changes in capacity. The idle test consists of an engine idling for extended periods under controlled conditions. Device flow will be checked periodically and correlated with road experience.

d. Ventilation and Oil Pullover - Run car at road load from 10 mph to 60 mph in 10 mph increments in highest gear, also idle in neutral and drive, 50 mph 6% grade 30 mph 16", 10", 2" Hg IMV. Measure oil pullover and fresh air ventilation at each condition. Measure crankcase vacuum or pressure at each condition.

J. Calculations for Air/Fuel Ratio Change

1. The evaluation for average change in engine air/fuel ratio attributable to the device will be made by calculations within each engine class, using:

   a. "Formula Air" (CFM) to approximate air flow of engines under 30 mph test conditions within the class (Table I).

   b. "Formula Blowby" in CFM presented in population decile form for each class in Table I.

   c. Weighted flow characteristics of device model sizes at 16", 10" and 2" Hg manifold vacuum. The flows of the applicable model sizes for the class are to be weighted proportion to California registration of applicable vehicles.

   d. Application of the appropriate formula following to determine percent change in air/fuel ratio:

   For upstream devices:

$$\text{Percent change} = \frac{\text{Formula Blowby}}{\text{Formula Air}} \times 100 \qquad (1)$$

   For downstream devices:

$$\text{Percent change} = \frac{\text{Formula Ventilation}}{\text{Formula Air}} \times 100 \qquad (2)$$

   e. Weighted results on the basis of .44 volumes at 30 mph - 16" .20 volumes at 10" and .22 volumes at 2" Hg manifold vacuum. It is presumed that correct idle readjustments will in fact be made upon installation.)

2. The appropriate method in the sequence below will be followed for a specific class application:

   a. Upstream device

   For the case where all blowby on all cars is returned upstream of the carburetor (with idle readjustment), the percent decrease in air/fuel ratio may be obtained directly at 16", 10" and 2" Hg. conditions from Table I, by classes. It will be noted that the enrichments shown substantially exceed the allowable 1%. Therefore, for applicants using this basic type of device, compensation means will have to be included in the device system. The applicant will show that the weighted flow characteristics, or average change in characteristics, as applicable to the means employed, will adequately compensate for upstream introduction of the blowby.

   b. Downstream device

   For each class in which certification is desired, calculate the average "Formula Ventilation." Average Formula Ventilation equals one-tenth of the sum of individual decile differences between corrected device flow and corresponding Formula Blowby, at each manifold vacuum. (If any of the decile differences are negative, they will be taken as zero.) Read "Formula Air" for same conditions (Table I). Calculate effect of device using Formula (2). Weight 0.44 for 16" + 0.20 at 10" + 0.22 at 2" Hg. = overall percent change in air/fuel ratio.

   c. Combination Device - (Closed System)

   For each displacement class calculate the difference between corrected device flow and average "Formula Blowby" at each manifold vacuum. Read Formula Air in Table I and calculate leaning by using Formula (2). Weight 0.44 at 16" = 0.20 at 10" + 2 Hg. for overall percent increase in air/fuel ratio. If difference is negative, air/fuel ratio is decreased by the overall percent so calculated.

K. Subsequent Modifications to Certified New and Used Car Emission Control Systems

Subsequent modifications to any certified emission control system shall be affirmed in writing by the staff prior to distribution of the modified system. To obtain such affirmation, the applicant shall submit technical information and qualified test data pertinent to the modification, and written representation signed by a legal officer stating that the modified system will comply with the Board's Criteria.

TABLE I

Car Class Allowable* ACFM at 110° F	Disp. cu. in.	Oper. Cond.	Formula Air ACFM @ 110° F 30" Hg	Formula Blowby, ACFM @ 110°F, 30" Hg (in population deciles) 1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	Avg.	Upstream Device Enrichment %
a 0.015	0-140	Idle	3	0.07	0.10	0.13	0.15	0.18	0.22	0.25	0.31	0.39	0.58	0.24	—
		16"	10	0.11	0.17	0.21	0.25	0.30	0.35	0.41	0.50	0.63	0.95	0.39	3.9
		10"	15	0.18	0.27	0.33	0.40	0.48	0.56	0.65	0.80	1.00	1.54	0.62	4.1
		2"	23	0.27	0.41	0.50	0.61	0.72	0.85	1.00	1.21	1.51	2.31	0.94	4.1
b 0.031	140-200	Idle	6	0.10	0.17	0.20	0.25	0.29	0.34	0.40	0.48	0.61	0.96	0.38	—
		16"	23	0.26	0.42	0.52	0.64	0.75	0.86	1.02	1.21	1.55	2.45	0.97	4.2
		10"	37	0.43	0.68	0.84	1.03	1.20	1.40	1.65	1.95	2.50	3.95	1.56	4.2
		2"	55	0.64	1.01	1.25	1.54	1.80	2.10	2.48	2.92	3.75	5.92	2.34	4.2
c 0.043	200-250	Idle	8	0.23	0.33	0.39	0.45	0.51	0.57	0.64	0.74	0.88	1.23	0.60	—
		16"	30	0.48	0.72	0.86	0.98	1.11	1.25	1.40	1.61	1.91	2.66	1.30	4.3
		10"	47	0.80	1.12	1.32	1.51	1.71	1.93	2.17	2.49	2.95	4.12	2.01	4.3
		2"	71	1.17	1.64	1.95	2.22	2.52	2.84	3.19	3.65	4.34	6.06	2.96	4.1
d 0.052	250-300	Idle	10	0.38	0.50	0.58	0.66	0.73	0.80	0.89	1.01	1.16	1.55	0.83	—
		16"	36	0.89	1.19	1.37	1.54	1.72	1.89	2.09	2.36	2.70	3.64	1.94	5.4
		10"	57	1.38	1.83	2.14	2.38	2.66	2.91	3.23	3.64	4.18	5.63	3.00	5.3
		2"	86	2.04	2.70	3.13	3.50	3.91	4.29	4.75	5.36	6.15	8.27	4.41	5.1
e 0.064	300-375	Idle	12	0.27	0.38	0.45	0.51	0.58	0.65	0.74	0.84	1.01	1.41	0.68	—
		16"	45	0.70	0.99	1.17	1.33	1.51	1.71	1.92	2.20	2.62	3.66	1.78	4.0
		10"	70	1.09	1.53	1.81	2.06	2.34	2.64	2.96	3.41	4.05	5.66	2.76	3.9
		2"	104	1.60	2.24	2.66	3.04	3.44	3.88	4.36	5.01	5.95	8.33	4.05	3.9
f 0.077	Over 375	Idle	14	0.20	0.27	0.33	0.37	0.42	0.48	0.54	0.62	0.73	1.03	0.50	—
		16"	53	0.62	0.86	1.02	1.17	1.32	1.48	1.68	1.93	2.28	3.19	1.56	2.9
		10"	82	0.96	1.33	1.58	1.80	2.04	2.30	2.60	2.99	3.52	4.94	2.41	2.9
		2"	122	1.41	1.96	2.33	2.66	3.01	3.38	3.82	4.40	5.18	7.26	3.54	2.9

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*Maximum allowable weighted ACFM Blowby outflow, based on 0.10% (Standard 10-23-64) of supplied fuel outflow, as 10,000 PPM hexane as measured by non-dispersive infrared analyzer.

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APPENDIX G

AMA DRIVEABILITY PROCEDURE

Based on "AMA Driveability Procedure,"
Revision 2, dated 13 September 1971
obtained from the Automobile
Manufacturers Association
320 New Center Building,
Detroit, Michigan

The subject of vehicle drive quality is likely the most subjective test procedure applied to vehicles in the industry. The judgment of acceptability varies from one vehicle type to another and from one model class or even model year to another. This variance is exercised based on anticipated customer requirements. The underlying attempt in a driveability quality test is to examine all of the conditions that all of the potential consumers of the specific model might be expected to encounter and then to accept only that "package" which satisfies these extremes. The term conditions refer to ambient, weather and operating conditions.

The industry does not have a "go no-go" type of test for driveability quality. In fact, the customer is the true measure of acceptability. Within each company a variety of hundreds of individual tests and value judgments constitute the final choice of product drive quality. Some of these tests are listed for your information (For definitions of terms, see page G-6).

a. Engine start quality

    1. At all temperatures between -20°F to 130°F

    2. At high altitude

    3. At high humidity (saturated)

b. Carburetor icing resistance at high humidity and a temperature of 40°F to 50°F

c. Hot fuel handling characteristics

    1. Vapor lock

    2. Percolation

    3. Accelerator pump slugging

    4. Accelerator pump "dry-out"

d. Choke performance

    1. Low ambient temperature start quality

    2. High ambient temperature start quality

    3. Loading tendency

    4. Restart quality — following soak

e. Idle quality under all conditions

f. Warmed-up drive quality

    1. Road load surge evaluation

    2. "Crowd" evaluation

    3. Wide open throttle response
    4. Part throttle and wide open throttle "tip-in" quality

g. Altitude evaluation

    1. Restart after soak
    2. Driveaway after soak

Test Vehicles

As a matter of technique, driveability tests are usually conducted on a so-called reference vehicle. For example, if a specific carburetor were to be evaluated it would be installed on a test vehicle with all electrical and mechanical components known to be within specifications. In this case, only the carburetor is considered to be a variable. The availability of a reference vehicle from a random consumer is reasonably remote since substitution of replacement parts, modification to adjustment specifications, and general deterioration all disqualify a vehicle.

Because driveability quality can be greatly different among the many vehicle combinations that are marketed, a reference evaluation seems most practical. The most direct approach to evaluating the effect of driveability of a "system" is to measure driveability of at least one vehicle with and without the "system."

An alternate procedure would be to evaluate the driveability of the vehicle with a "system" installed and compare to a standard or reference vehicle. For this comparison, the reference or "identical" vehicle(s) should be selected to have the following characteristics compared to the vehicle to be evaluated:

a. Same manufacturer and model year

b. Same engine displacement, transmission type, axle ratio and tire size

c. Same nominal compression ratio and carburetor size

d. Approximately the same mileage

e. Approximately the same engine driven accessories (e.g. air conditioning)

In addition the following characteristics are necessary for the reference vehicle:

a. Manufacturer's specified production or service components to include fuel and carburetor system, ignition system, and cooling system

b. Manufacturer's specified tuneup adjustments

c. Same fuel and lubricants used in both vehicles

NOTE: The driver for both the reference and evaluation vehicle should be the same. An experienced evaluator should be used whenever possible.

Scope

It is recognized that from a practical standpoint, this driveability evaluation need not be as comprehensive as those used by the manufacturer. Listed below is a driving procedure recommended for both the system equipped vehicle and the reference vehicle. This procedure is intended as an initial screening test and is not adequately comprehensive to determine manufacturers' total acceptance.

Procedure

Attached to the procedure are data sheets which are keyed to the procedure so that a driver and observer can readily follow the procedure. The merit or quality of a vehicle tested can be determined by the check mark locations (e.g. satisfactory, trace, moderate or heavy) for a given problem area.

For desirable repeatability, a level smooth-surface road, free of traffic interference should be selected.

INITIAL SCREENING PROCEDURE FOR VEHICLE DRIVEABILITY

I. Vehicle Preparation

A. Install tachometer and vacuum gauge - warmup vehicle (minimum 5 miles, driving).

B. Set engine and vehicle to manufacturers' specification.

C. Park overnight or equivalent soak period (8 hour minimum), with vehicle positioned to facilitate straight out driveaway.

II. Cold Start and Driveaway Procedure

See Data Sheet

A. Start engine per Owner's Manual Procedure.

B. Record engine RPM in neutral or park immediately after start, with foot removed from throttle pedal. Idle 20 sec.

C. Record idle quality and/or number of stalls.

D. Accelerate engine briefly, and again release throttle and record engine RPM (neutral) - Record idle quality and/or number of stalls. Idle 10 sec.

E. On automatic transmission vehicles, place selector in normal drive range and record engine RPM, idle quality and stalls. Equivalent time between start and driveaway should be used when comparing vehicles. Idle 5 sec.

F. Make a moderate acceleration to 25 MPH -For manual transmissions, shift through the normal pattern, to a high gear* cruising speed of 25 MPH. Accelerate WOT from 25 MPH to 35 MPH, decelerate 35-25 MPH and accelerate at 1/2 to 3/4 throttle to 30 MPH, then repeat the last two sequences twice.

G. Note and record any malfunctions such as the following:

1. Stalls
2. Backfires
3. Hesitations
4. Stumbles

H. At 0.5 mile from start, brake moderately to a stop. Idle for 30 seconds. Observe idle quality and engine speed in drive range (AT) or clutch disengaged (MT).

I. Repeat steps F, G and H through 5.0 miles from start.

III. Warm Vehicle Driveability Procedure

(See data sheet at the end of this appendix)

A. Warm up vehicle for approx. 10 miles at freeway speeds.

B. Curb idle evaluation in drive gear for automatic transmission (note quality, speed and vacuum).

C. Road load operation from 20 through 70 MPH.

D. With automatic transmission vehicle, make the indicated WOT accelerations from 0 through 30 MPH. With manual transmission vehicle accelerate in high gear from 20 through 30 at WOT.

E. With automatic transmission vehicle, make the indicated accelerations from 0 through 30 MPH at various constant throttle positions from very light to nearly WOT. With manual transmission vehicle these PT accelerations are to be made from 20 through 30 MPH.

F. "Crowds" are evaluated in high gear from 20 MPH through 70 MPH by accelerating at a continually increasing throttle opening. Several runs should be made varying the rate of throttle opening.

---

*High gear is that recommended by the manufacturer for this event.

G. Evaluate the "tip-in" characteristics by making several PT accelerations from 20 and 30 MPH. Do not accelerate at a load which will cause the automatic transmission to down-shift.

H. After three consecutive WOT accelerations from 0 through 70 MPH - idle for 30 seconds.

I. Shut off engine and soak for 15 minutes. Restart at 1/2 throttle (record time) and hold at 1500 RPM for three seconds, return to idle, maintain idle for 10 seconds in Neutral and, for AT, 10 seconds in Drive. Run WOT acceleration 0-70 MPH and record time of acceleration.

J. Engine coast conditions are evaluated from 70 to 30 MPH at closed throttle (record time). If necessary run in opposite directions to cancel effect of wind.

DEFINITIONS OF TERMS APPLICABLE TO ATTACHED DRIVEABILITY PROCEDURE

1. Road Load - A fixed throttle position which maintains a constant vehicle speed on a level road.

2. Coast - Deceleration at closed (curb idle) throttle.

3. Wide Open Throttle (WOT) Acceleration - An acceleration made entirely at wide open throttle (from any speed).

4. Part Throttle (PT) Acceleration - An acceleration made at any fixed throttle position less than WOT.

5. Tip-In - Vehicle response (up to two seconds in duration), to the initial opening of the throttle.

6. Crowd - An acceleration made at a continually increasing throttle opening.

7. Idle Quality - An evaluation of vehicle smoothness, with the engine at curb idle in drive, as judged from the driver's seat.

8. Backfire - An explosion in the induction or exhaust system.

9. Hesitation - A temporary lack of initial response in acceleration rate.

10. Stumble - A short, sharp reduction in acceleration rate.

11. Lean Operation - This condition, depending on its severity, can manifest itself as outlined in the following categories:

    A. Stretchiness - A lack of anticipated response to throttle movement. This may occur on slight throttle movement from road load or during light to moderate accelerations.

B. Surging - A condition of leanness, resulting in short, sharp fluctuations. These may be cyclic or random and can occur at any speed and/or load.

12. After-run - A condition where the engine continues to run after the ignition has been shut off.

13. Detonation (spark knock) - A knock or ping which is recurrent or repeatable in terms of audibility.

Layman's Nomenclature

Performance Factor	Performance Defects
Acceleration (pickup)	Acceleration defects are usually associated with lack of proportional response of the vehicle to a movement of the accelerator pedal (gas pedal). This lack of response will vary depending on the type of defect, for example; Stumble - a short, sharp reduction in acceleration. Hesitation - a temporary lack of vehicle response to the initial movement of the accelerator pedal. Stretchiness - a lack of expected response of the vehicle to a slight movement of the accelerator pedal that is intended to produce a slight acceleration. Surging - an uneven, fluctuating response of the vehicle to a slight movement of the accelerator that is intended to produce a slow acceleration. Infrequently, surging will occur with a larger accelerator movement. Backfire - a sharp noise resulting from a fuel mixture explosion occurring either in the engine induction or exhaust system. Stalling - a complete stoppage of the engine.
Constant Speed Driving	Surging - an uneven, fluctuating sensation resulting from erratic changes in vehicle velocity. This defect is most easily detected on smooth roads and is usually masked by uneven roads.

Engine Starting	Delayed Start - an engine start that is longer than the anticipated starting time, or exceeding the capacity of the engine cranking system and battery. Partial Start (stalling) - one or more engine stalls occurring immediately or shortly after the initial start. Backfire - may occur during the starting operation.
Deceleration (slow down)	Surging - may also occur on deceleration when the accelerator pedal is still slightly depressed. Backfire - may occur with the foot entirely removed from the accelerator. Stalling - complete stoppage of the engine may occur just prior to or at the time the vehicle comes to a stop.
Engine Noise	Detonation (spark knock) - an abnormal noise in the engine resembling a series of sharp raps, knocks or pings - may occur at constant speed, or when accelerating or when climbing hills.
Vehicle Shutdown	After run - is a condition where the engine continues to run after the key is turned off.

COLD START AND DRIVEAWAY EVALUATION

SHEET 1 OF 2

VEHICLE NO. ____________ LICENSE NO. ____________

DATE: ____________ TIME: START ________ FINISH ________ ODO.: START ______ FINISH ______

VEHICLE	ENGINE	WEATHER	CREW
MAKE ________	DISP. ______ TYPE ______	TEMP.: START °F ______	DRIVER: ________
MODEL ________	NOM. C.R. ________	END °F ______	RECORDER: ________
YEAR ________	CARB.: MFG. ________	ROAD CONDITIONS:	OBSERVER (S): ________
TRANS. ______ A/C ______	MODEL ________	WET ______ DRY ______	________
P/B ______ P/S ______	CHOKE: ________	SOAK TIME (HRS) ______	________

REMARKS: ____

START TIME (SEC) ATTEMPTS

MILES	MODE	RPM	IDLE			ACCEL					*BACK FIRE		
			SATIS.	ROUGH*	STALL	SATIS.	HESIT.*	STUMBLE*	STALL	LEAN*	STRETCH.	SURGE	
START	FAST IDLE CAM 20												
	TAP THROTTLE N 10												
	DR 5												
0	PT ACCEL (0 - 25)												
0.1	WOT ACCEL (25 - 35)												
0.2	PT ACCEL (25 - 30)												
0.3	PT ACCEL (25 - 30)												
0.4	PT ACCEL (25 - 30)												
0.5	IDLE (30 SEC.)												
	PT ACCEL (0 - 25)												
0.6	WOT ACCEL (25 - 35)												
0.7	PT ACCEL (25 - 30)												
0.8	PT ACCEL (25 - 30)												
0.9	PT ACCEL (25 - 30)												
1.0	IDLE (30 SEC.)												
	PT ACCEL (0 - 25)												
1.1	WOT ACCEL (25 - 35)												
1.2	PT ACCEL (25 - 30)												
1.3	PT ACCEL (25 - 30)												
1.4	PT ACCEL (25 - 30)												
1.5	IDLE (30 SEC.)												
	PT ACCEL (0 - 25)												
1.6	WOT ACCEL (25 - 35)												
1.7	PT ACCEL (25 - 35)												
1.8	PT ACCEL (25 - 30)												
1.9	PT ACCEL (25 - 30)												
2.0	IDLE (30 SEC.)												
	PT ACCEL (0 - 25)												
2.1	WOT ACCEL (25 - 35)												
2.2	PT ACCEL (25 - 30)												
2.3	PT ACCEL (25 - 30)												
2.4	PT ACCEL (25 - 30)												

MILES	MODE	RPM	IDLE			ACCEL					*BACK FIRE		
			SATIS.	ROUGH*	STALL	SATIS.	HESIT.*	STUMBLE*	STALL	LEAN*	STRETCH.	SURGE	
2.5	IDLE (30 SEC.)												
	PT ACCEL (0 - 25)												
2.6	WOT ACCEL (25 - 35)												
2.7	PT ACCEL (25 - 30)												
2.8	PT ACCEL (25 - 30)												
2.9	PT ACCEL (25 - 30)												
3.0	IDLE (30 SEC.)												
	PT ACCEL (0 - 25)												
3.1	WOT ACCEL (25 - 35)												
3.2	PT ACCEL (25 - 30)												
3.3	PT ACCEL (25 - 30)												
3.4	PT ACCEL (25 - 30)												
3.5	IDLE (30 SEC.)												
	PT ACCEL (0 - 25)												
3.6	WOT ACCEL (25 - 35)												
3.7	PT ACCEL (25 - 30)												
3.8	PT ACCEL (25 - 30)												
3.9	PT ACCEL (25 - 30)												
4.0	IDLE (30 SEC.)												
	PT ACCEL (0 - 25)												
4.1	WOT ACCEL (25 - 35)												
4.2	PT ACCEL (25 - 30)												
4.3	PT ACCEL (25 - 30)												
4.4	PT ACCEL (25 - 30)												
4.5	IDLE (30 SEC.)												
	PT ACCEL (0 - 25)												
4.6	WOT ACCEL (25 - 35)												
4.7	PT ACCEL (25 - 30)												
4.8	PT ACCEL (25 - 30)												
4.9	PT ACCEL (25 - 30)												
5.0	IDLE (30 SEC.)												

*T - TRACE; M - MODERATE; H - HEAVY

WARM VEHICLE DRIVEABILITY EVALUATION

10-16-68

SHEET 2 OF 2

VEHICLE NO. ______________________ LICENSE NO. ______________________

DATE: ____________ TIME: START ____________ FINISH ____________ ODO.: START ____________ FINISH ____________

TEMP.: START ________ °F FINISH ________ °F

ROAD CONDITION: WET ____________ DRY ____________

HUMIDITY ____________

REMARKS: ____

	RPM	VAC	IDLE			DRIVE MODES					
			SATISFACTORY	ROUGH*	STALL	SATISFACTORY	DETONATION*	SURGE*	HESITATION	STRETCHINESS	BACKFIRE
CURB IDLE											
ROAD LOAD 20 MPH											
30											
40											
50											
60											
70											
WOT ACCEL)20 - 30 MANUAL TRANS)0 - 30 AUTO TRANS											
SUDDEN THROTTLE OPENING											
MODERATE THROTTLE OPENING											
SLOW THROTTLE OPENING											
PT ACCEL)20 - 30 MANUAL TRANS)0 - 30 AUTO TRANS											
1/4 THROTTLE											
1/2 THROTTLE											
3/4 THROTTLE											
PT CROWD 20 - 40											
15 IN. HG											
10 IN. HG											
5 IN. HG											
PT TIP-IN											
FROM 20 MPH 1											
2											
FROM 30 MPH 1											
2											

SOAK START TIME ATTEMPTS:

IDLE N ____________ RPM ____________ VAC ____________ AFTER-RUN YES ____________

D RPM VAC NO ____________

ACCELERATION TIME 0 - 60 MPH (SEC.)

DECELERATION TIME 70 - 40 MPH (SEC.) BACKFIRE

*T - TRACE; M - MODERATE; H - HEAVY

APPENDIX H

COMPUTER PROGRAM PRINTOUT FOR ANALYTICAL METHODOLOGY

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LEVEL 18 ( SEPT 69 )                              OS/360  FORTRAN H       DATE  72.083/10.40.25

          COMPILER OPTIONS - NAME=  MAIN,OPT=00,LINECNT=42,SIZE=0000K,
                             SOURCE,EBCDIC,NOLIST,NODECK,LOAD,MAP,NOEDIT,ID,NOXREF
                C
                C     RETROFIT DEVICE COMPARATIVE ANALYSIS PROGRAM (REDCAP)
                C
                C     L. MOORE, ENVIRONMENTAL SYSTEMS, NORTHROP CORP.
                C
                C     THIS PROGRAM IMPLEMENTS THE PERFORMANCE ANALYSIS INDEX EQUATION
                C     FOR RANKING RETROFIT EMISSION CONTROL DEVICES.
                C
                C     THE PROGRAM ALSO CALCULATES MASS VALUES FOR HC, CO, AND NOX
                C     FROM CVS CONCENTRATION VALUES.
                C
                C     IMPORTANT VARIABLES AND ARRAYS
                C
                C      DEVICE DATA
                C
                C       DD (M, 1) - CLAIMED NUMBER OF EMISSION STANDARDS MET
                C       DD (M, 2) - DEVICE COST OVER ITS EXPECTED LIFE, IN $/MILE
                C       DD (M, 3) - SAFETY INDEX
                C       DD (M, 4) - MEAN MILEAGE BEFORE DEVICE FAILURE
                C       DD (M, 5) - MEAN TIME TO REPAIR DEVICE FAILURE, HOURS
                C       DD (M, 6) - MEAN MILEAGE TO PERIODIC MAINTENANCE
                C       DD (M, 7) - MEAN TIME TO PERFORM PERIODIC MAINTENANCE, HOURS
                C       DD (M, 8) - MEAN MILEAGE BEFORE PARTIAL DEVICE FAILURE
                C       DD (M, 9) -
                C       DD (M,10) - FAILED PART COST
                C       DD (M,11) - PERIODIC REPLACEMENT PART COST
                C       DD (M,12) - RETAIL COST OF BASIC DEVICE
                C       DD (M,13) - INSTALLATION COST, HOURS
                C       DD (M,14) - ADAPTATION COST (IF ANY)
                C       DD (M,15) -
                C       DD (M,16) - DEVELOPMENT STATUS
                C       DD (M,17) - ADAPTABILITY, % OF POPULATION
                C       DD (M,18) -
                C       DD (M,19) - EXPECTED DEVICE LIFE , IN MILES
                C       DD (M,20) - DEVICE FILE NUMBER
                C
                C      COLD DRIVABILITY DATA, NET
                C
                C       DC (N, 1) - TEST ID CODE
```

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```
C       DC (N, 2) - COLD CRANKING TIME AVERAGE
C       DC (N, 3) - NUMBER OF ATTEMPTS TO START VEHICLE COLD
C       DC (N, 4) - ROUGH IDLE COLD
C       DC (N, 5) - COLD IDLE STALL
C       DC (N, 6) - STALL ON ACCELERATION
C       DC (N, 7) - BACKFIRE ON ACCELERATION
C       DC (N, 8) - STUMBLE ON COLD ACCELERATION
C       DC (N, 9) - HESITATION ON COLD ACCELERATION
C       DC (N,10) - DETONATION ON COLD ACCELERATION
C       DC (N,11) - STRETCHINESS ON COLD ACCELERATION
C       DC (N,12) - SURGING ON ACCELERATION
C
C      HOT DRIVABILITY DATA, NET
C
C       DH (N, 1) - TEST ID CODE
C       DH (N, 2) - HOT CRANKING TIME AVERAGE
C       DH (N, 3) - NUMBER OF ATTEMPTS TO START VEHICLE HOT
C       DH (N, 4) - ROUGH IDLE HOT
C       DH (N, 5) - HOT IDLE STALL
C       DH (N, 6) - STALL IN DRIVE MODES
C       DH (N, 7) - BACKFIRE IN DRIVE MODES
C       DH (N, 8) - STUMBLE IN DRIVE MODES
C       DH (N, 9) - HESITATION IN DRIVE MODES
C       DH (N,10) - DETONATION IN DRIVE MODES
C       DH (N,11) - STRETCHINESS IN DRIVE MODES
C       DH (N,12) - SURGING IN DRIVE MODES
C
C      DRIVABILITY COEFFICIENT TERMS
C
C       DA( 1) - ROUGH IDLE COLD
C       DA( 2) - STALL IDLE COLD
C       DA( 3) - STUMBLE COLD
C       DA( 4) - HESITATION COLD
C       DA( 5) - DETONATION COLD
C       DA( 6) - STRETCHINESS COLD
C       DA( 7) - SURGE COLD
C       DA( 8) - ROUGH IDLE HOT
C       DA( 9) - STUMBLE HOT
C       DA(10) - HESITATION HOT
C       DA(11) - DETONATION HOT
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C        DA(12) - STRETCHINESS HOT
C        DA(13) - SURGE HOT
C        DA(14) - COLD START TIME
C        DA(15) - HOT  START TIME
C        DA(16) - ACCELERATION
C
C       AS RECEIVED TEST RESULTS
C
C        ARHC  (N) - AS RECEIVED HC , GM/MI
C        ARCO  (N) - AS RECEIVED CO , GM/MI
C        ARCO2 (N) - AS RECEIVED CO2, GM/MI
C        ARNOX (N) - AS RECEIVED NOX, GM/MI
C        ARGAS (N) - FUEL CONSUMPTION
C
C       BASELINE AND RETROFIT TEST RESULTS
C
C        EMD(N,M, 1) - BASELINE TEST ID, FRCM DC(N, 1)
C        EMD(N,M, 2) - BASELINE HC  GM/MI
C        EMD(N,M, 3) - BASELINE CO  GM/MI
C        EMD(N,M, 4) - BASELINE CO2 GM/MI
C        EMD(N,M, 5) - BASELINE NOX GM/MI
C        EMD(N,M, 6) - DEVICE TEST ID, FROM DC(N, 1)
C        EMD(N,M, 7) - DEVICE HC  GM/MI
C        EMD(N,M, 8) - DEVICE CO  GM/MI
C        EMD(N,M, 9) - DEVICE CO2 GM/MI
C        EMD(N,M,10) - DEVICE NOX GM/MI
C        EMD(N,M,11) - EMISSION INDEX
C        EMD(N,M,12) - DRIVABILITY INDEX
C        EMD(N,M,13) - COST INDEX
C        EMD(N,M,14) - BASELINE FUEL CONSUMPTION
C        EMD(N,M,15) - DEVICE FUEL CONSUMPTION
C        EMD(N,M,16) - PERFORMANCE INDEX
C        EMD(N,M,17) - COST-EFFECTIVENESS INDEX
C        EMC(N,M,18) -
C
C       AVERAGE INDEX AND SUB-INDEX VALUES FOR DEVICE M
C
C        DEX (M, 1) - PERFORMANCE INDEX
C        DEX (M, 2) - CRITERIA INDEX
C        DEX (M, 3) - SAFETY INDEX
```

```
                C       DEX (M, 4) - CRITICAL DRIVABILITY FACTOR
                C       DEX (M, 5) - EMISSION STANDARDS FACTOR
                C       DEX (M, 6) - HC  REDUCTION FROM STD, GM/MI
                C       DEX (M, 7) - CO  REDUCTION FROM STD, GM/MI
                C       DEX (M, 8) - NOX REDUCTION FROM STD, GM/MI
                C       DEX (M, 9) - GENERAL DRIVABILITY FACTOR
                C       DEX (M,10) - INSTALLATION COST FACTOR
                C       DEX (M,11) - RECURRING COST FACTOR
                C       DEX (M,12) - FUEL MILEAGE LOSS, MPG
                C       DEX (M,13) - RELIABILITY FACTOR
                C       DEX (M,14) - MAINTAINABILITY FACTOR
                C       DEX (M,15) - AVAILABILITY FACTOR
                C       DEX (M,16) - EMISSION BASELINE FACTOR
                C       DEX (M,17) - HC  REDUCTION FROM BASELINE, %
                C       DEX (M,18) - CO  REDUCTION FROM BASELINE, %
                C       DEX (M,19) - NOX REDUCTION FROM BASELINE, %
                C       DEX (M,20) - EMISSION PERFORMANCE INDEX
                C       DEX (M,21) - DRIVABILITY PERFORMANCE INDEX
                C       DEX (M,22) - COLD START PENALTY, WEIGHTED SUM
                C       DEX (M,23) - HOT  START PENALTY, WEIGHTED SUM
                C       DEX (M,24) - ACCELERATION LOSS, SECONDS
                C       DEX (M,25) - COST INDEX, DOLLARS PER MILE
                C       DEX (M,26) - DEVICE COST, INSTALLED
                C       DEX (M,27) - COST-EFFECTIVENESS INDEX
                C
                C
                C
                C
                C
ISN 0002              REAL MHC,MCO,MCO2,MNOX,MMBF,MTTR,MMTM,MTTM,MPYR,MMBPF
ISN 0003              INTEGER ESMC,TESTID,DESC
ISN 0004              INTEGER A/'A'/,B/'B'/,                       ZERO/'0'/
ISN 0005              DIMENSION PER(20,2),PERB(2),PERD(2),DEX(12,27),DKT(12)
ISN 0006              DIMENSION STAB(6,5),DESC(20,20),DC(20,15),DH(20,15),DCWF(15),
                     1          DHWF(15),DCW(20,15),DHW(20,15),DD(12,20),DA(16),
                     2          DCD(15),DHD(15),DCB(15),DHB(15),DECK(12,8),REC(12)
ISN 0007              DIMENSION INPUT(80),EMD(20,12,20),PERFI(20,12), DES(20),
                     1                ARHC(20),ARCO(20),ARCO2(20),ARNO(20),ARGAS(20)
ISN 0008              DIMENSION DC2(15),DC3(15),DH2(15),DH3(15),PER2(2),PER3(2)
ISN 0009              DATA DC2/15*0./,DC3/15*0./,DH2/15*0./,DH3/15*0./,
                     1       PER2/2*0./,PER3/2*0./
ISN 0010              DATA DCB/15*0./,DCD/15*0./,DHB/15*0./,DHD/15*0./,
                     1       PERB/2*0./,PERD/2*0./
ISN 0011              DATA M/0/,          EI/1./,         DI/1./,CII/1./,CEI/1./
ISN 0012              DATA ARHC/20*0./,EMD/4800*0./,DD/240*0./,PERFI/240*0./
ISN 0013              DATA ARCC/20*0./,ARNO /20*0./,ARGAS/20*0./
ISN 0014              DATA DEX/324*0./,DKT/12*0./,DECK/96*0./
ISN 0015              DATA ERROR/0.1/,ETA/1.0/
ISN 0016              COMMON STAB,AK0,AK1,TWET,TDRY,H,HUCF
                C
                C     INPUT ROUTINE
                C
ISN 0017              CALL REREAD
                C
ISN 0018              WRITE(6,2000)
ISN 0019        2000  FORMAT('1')
ISN 0020              WRITE(6,2001)
ISN 0021        2001  FORMAT('1',
                     1          T 5,'PERFORMANCE ANALYSIS REPORT FOR RETROFIT DEVICES
                     1TESTED'///T 7,'THE CONSTANTS USED FOR THIS RUN ARE:'/ )
ISN 0022              READ(5,1000) ((STAB(I,J), J=1,5),I=1,6)
ISN 0023        1000  FORMAT (2(F6.1,F6.2,2F7.1,F7.4,7X))
ISN 0024              READ(5,1010) AK0,AK1,DK0,DK1
ISN 0025        1010  FORMAT (4F10.6)
ISN 0026              READ(5,1020) ESHC,ESCO,ESNO,RELMIN,AVSPD,DDELT,CLI,CLAB,RCSTD,
                     1               MPYR,GAS,CREIM,CLR,AVAIL
ISN 0027        1020  FORMAT (3F8.1,7F8.0/4F8.5)
ISN 0028              AVAIL = MPYR
ISN 0029              CLR = RCSTD/MPYR
ISN 0030              NCAR = 0
ISN 0031              LINE = 50
ISN 0032              AREP = 1.
ISN 0033              ER   = ERROR*100.
ISN 0034              WRITE(6,1021)ESHC,ESCO,ESNO,ER,ETA,RELMIN,AVAIL,MPYR,CLI,CLAB,
                     1               RCSTD,CLR,GAS
ISN 0035        1021  FORMAT (T10,'COMPARISON LIMITS FOR HC,CO, AND NOX IN GM/MI ARE,',
                     1          3F8.1/
                     1          T10,'MAXIMUM ALLOWED EMISSION INCREASE FROM BASELINE DUE T
                     +O EXPERIMENTAL ERROR, %',F6.1/
                     1          T10,'MAXIMUM DRIVEABILITY INDEX ALLOWED FOR CRITERIA INDEX
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                        +',F5.1/
                        1          T10,'MINIMUM RELIABILITY ALLOWED, IN MILES',F8.0/
                        2          T10,'MINIMUM AVAILABILITY ALLOWED, IN MI/REPAIR HOUR',F8.0
                        3/         T10,'AVERAGE MILES PER YEAR CRIVEN',F8.0/
                        5          T10,'DEVICE COST LIMIT, INSTALLED',F5.0,'  DOLLARS'/
                        6          T10,'HOURLY LABOR RATE, DOLLARS',F7.2/
                        7          T10,'RECURRING COST LIMIT, DOLLARS PER YEAR',F5.0/
                        8          T10,'RECURRING COST LIMIT, DOLLARS PER MILE',F8.5/
                        9          T10,'AVERAGE FUEL COST, DOLLARS PER GALLON',F6.3/)
ISN 0036                 READ(5,1025) BH ,BC ,BN ,GAMHCA,GAMCOA,GAMNOA,GAMHC,GAMCC,GAMNO,
                        1          GDA,BAV
ISN 0037          1025  FORMAT (11F5.3)
ISN 0038                WRITE(6,1026) BH,BC,BN
ISN 0039          1026  FORMAT((T10,'THE EMISSION WEIGHTING FACTORS ARE:'      ,3F8.3)/)
ISN 0040                READ (5,1030)   (DCWF( I),I=1, 9)
ISN 0041          1030  FORMAT ( 9F5.3)
ISN 0042                READ (5,1030)   (DHWF( I),I=1, 9)
ISN 0043                READ(5,1040) (DA (I),I=1,16)
ISN 0044          1040  FORMAT (13F6.4,/3F6.4)
ISN 0045                WRITE(6,1041)(DA (I),I=1,16)
ISN 0046          1041  FORMAT((T10,'THE DRIVABILITY COEFFICIENT TERMS ARE:'/T10,16F7.4)/)
ISN 0047                ASUM = 0.
ISN 0048                DO 7 I3=1,16
ISN 0049                ASUM = ASUM + DA(I3)
ISN 0050             7  CONTINUE
ISN 0051                READ (5,1045) WT1,WT2,WT3
ISN 0052          1045  FORMAT (3F5.0)
ISN 0053                WRITE(6,1046) WT1,WT2,WT3
ISN 0054          1046  FORMAT((T10,'THE EI, DI, AND CI WEIGHTING FACTORS ARE:',3F8.3)/)
ISN 0055             8  M = M + 1
ISN 0056                DEX (M,2) = 1.0
ISN 0057                DEX (M,4) = 1.0
ISN 0058                DEX (M,9) = 1.0
ISN 0059                READ(5,1050) DD(M,20),(DD(M,J),J=1,17)
ISN 0060          1050  FORMAT (F4.0,
                       1 3F2.0,2(F7.1,F4.2),F7.1,F3.0,2F5.2,F6.2,F4.2,2F5.2,F2.0,F5.2)
ISN 0061                IF(DD(M,1) .EQ. 0.) GO TO 6
ISN 0063                WRITE(6,1051) M,(DD(M,J), J=1,20)
ISN 0064          1051  FORMAT (T10,'THE DEVICE DATA FOR DEVICE NUMBER ',I3/
                       1 T10,      3F4.0,2(F9.0,F6.2),F9.0,F4.0,3F7.2,F6.2,F7.2,2F4.0,F7.2
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```
                   +,2F4.0,F6.0)
              C       AVAILABILITY INDEX
ISN 0065              IF (DD(M,6) .EQ. 0.) DD(M,6) = 1.0E+06
ISN 0067              MMBF = DD(M,4)
ISN 0068              MTTR = DD(M,5)
ISN 0069              MMTM = DD(M,6)
ISN 0070              MTTM = DD(M,7)
ISN 0071              MMBPF = DD(M, 8)
ISN 0072              R = 0.0
ISN 0073              IF(MMBF.GE.RELMIN)  R = 1.0
ISN 0075              EM = 0.0
ISN 0076              IF(MMTM.GE.MPYR  ) EM = 1.0
ISN 0078              APRM =MMBPF/(MTTR + MTTM*(MMBPF/MMTM))
ISN 0079              A  = 0.0
ISN 0080              IF(APRM.GE.AVAIL)  A  = 1.0
ISN 0082              DEX (M,13) = R
ISN 0083              DEX (M,14) = A
ISN 0084              DEX (M,15) = EM
              C       INITIAL COST INDEX
ISN 0085              CDI = DD(M,12) + DD(M,13)*CLAB + DD(M,14)
ISN 0086              EPS = 1.0
ISN 0087              IF(CDI.GT.CLI) EPS = 0.0
ISN 0089              DEX (M,10) = EPS
ISN 0090              IF (DD(M,19) .EQ. 0.) DD(M,19) = MMBF
ISN 0092              CII = CDI/DD(M,19)
ISN 0093              DD (M, 2) = CII
ISN 0094              DEX (M,26) = CDI
ISN 0095              DEX (M, 3) = DD (M, 3)
ISN 0096              GO TO 8
ISN 0097            6 CONTINUE
ISN 0098              WRITE(8,1052)
ISN 0099      1052   FORMAT ('1',T5, 'EMISSION AND DRIVABILITY TEST DATA'//
                     +T10,'*** NOTE ***  ALL ITEMS INPUT ON CARDS MUST BE FILLED WITH DA
                     +TA. IF INCOMPLETE OR INVALID, THE OUTPUT RESULTS '/T10,'AFFECTED B
                     +Y THAT INPUT WILL ALSO BE INVALID BUT WILL BE PRINTED.'//)
ISN 0100            9 READ(5,1055) INPUT
ISN 0101      1055   FORMAT(80A1)
ISN 0102              WRITE(8,1056) INPUT
ISN 0103      1056   FORMAT (T10,80A1)
ISN 0104              IF (INPUT(1) .EQ. A) GO TO 10
ISN 0106              IF (INPUT(1) .EQ. B) GO TO 11
ISN 0108              IF (INPUT(1) .EQ. ZERO)  GO TO 915
ISN 0110           10 READ (99,1060) N,IMO,IDA,IYR,IWET,IDRY,PBAR,ODO,NRUNA,TESTID
ISN 0111      1060  FORMAT (5X, I6,3I2,   2I2,F5.2,12X,I6,1X,I6,10X,I4)
ISN 0112            VR = 0.
ISN 0113            TWET = IWET
ISN 0114            TDRY = IDRY
ISN 0115            MT = TESTID - (TESTID/10)*10
ISN 0116            IF (MT .EQ. 1) GO TO 120
ISN 0118            M = 0
ISN 0119            AM = TESTID/10
ISN 0120            DO 112 ID=1,11
ISN 0121            IF(AM .EQ. DD(ID,20)) M = ID
ISN 0123        112 CONTINUE
ISN 0124            IF( M .EQ. 0)  GO TO 900
ISN 0126        120 NN = N - (N/1000)*1000
ISN 0127            LOC = N/10000
ISN 0128            N  = NN
ISN 0129        111 CONTINUE
ISN 0130            GO TO 9
ISN 0131         11 READ (99,1070) I1,I2,NRUNB,    TMIX,PIN,POUT,VR,REV,FUEL,
                  1                 AHC,ACO,ACO2,ANOX,BHC,BCO,BCO2,BNOX
ISN 0132      1070  FORMAT (1X,2I1,I6,F3.0,2F5.2,F5.4,F5.0,F5.2,F4.0,F5.0,F4.2,F4.0,
                  1         F3.0,1X,F5.0,F4.2,F4.0)
ISN 0133         15 CONTINUE
ISN 0134            CHC  = AHC - BHC
ISN 0135            CCO  = (ACO - BCO)/10000.
ISN 0136            CCO2 = (ACO2 - BCO2)/10000.
ISN 0137            CNOX = ANOX - BNOX
ISN 0138            CALL MASS(PBAR,PIN,POUT,TMIX,REV,CHC,CCO,CCO2,CNOX,VR,
                  1           MHC,MCO,MCO2,MNOX)
ISN 0139            IF ( MT .EQ. 1 ) GO TO 17
ISN 0141            IF ( MT .EQ. 3 ) GO TO 20
ISN 0143            IF ( MT .NE. 2 ) GO TO 900
              C     TEST RESULTS, BASELINE
              C     READ IN BASELINE DRIVABILITY
ISN 0145         16 CONTINUE
ISN 0146            READ (5,1076) (DC2( I),I=1,14), (DH2( I),I=2,15) ,(PER2( I),I=1,2)
ISN 0147      1076  FORMAT (F4.0,F3.1,12F2.0,2X,F3.1,13F2.0,2F4.1)
ISN 0148            WRITE(8,1077) (DC2( I),I=1,14), (DH2( I),I=2,15) ,(PER2( I),I=1,2)
ISN 0149      1077  FORMAT (T10,
                  1         F6.0,F5.1,12F3.0,2X,F5.1,13F3.0,2F6.1)
ISN 0150            DC(N,1) = DC2(1)
ISN 0151          DH(N,1) = DC(N,1)
ISN 0152          EMD(N,M,1) = DC(N,1)
ISN 0153          EMD(N,M,2) = (
                 1EMD(N,M,2) + MHC)/AREP
ISN 0154          EMD(N,M,3) = (
                 1EMD(N,M,3) + MCO)/AREP
ISN 0155          EMD(N,M,5) = (
                 1EMD(N,M,5) + MNOX)/AREP
            C     CONVERT - MILES*(LB/GAL)/(LB)
ISN 0156          GAMB = 7.5     *6.17/(FUEL)
ISN 0157          EMD(N,M,14) = (
                 1EMD(N,M,14) + GAMB)/AREP
ISN 0158          GO TO 9
ISN 0159       17 ARHC  (N) = MHC
ISN 0160          ARCO  (N) = MCO
ISN 0161          ARCO2 (N) = MCO2
ISN 0162          ARNO  (N) = MNOX
ISN 0163          ARGAS (N) = 7.5*6.17/(FUEL)
ISN 0164          GO TO 9
ISN 0165       20 CONTINUE
            C     TEST RESULTS, DEVICE INSTALLED
            C     READ IN DRIVABILITY WITH DEVICE INSTALLED
ISN 0166          READ (5,1076) (DC3( I),I=1,14), (DH3( I),I=2,15),(PER3( I),I=1,2)
ISN 0167          WRITE(8,1077) (DC3( I),I=1,14), (DH3( I),I=2,15),(PER3( I),I=1,2)
ISN 0168          DC(N,1) = DC3(1)
ISN 0169          EMD(N,M, 6) = DC(N,1)
ISN 0170          EMD(N,M, 7) = (
                 1EMD(N,M, 7) + MHC)/AREP
ISN 0171          EMD(N,M, 8) = (
                 1EMD(N,M, 8) + MCO)/AREP
ISN 0172          EMD(N,M,10) = (
                 1EMD(N,M,10) + MNOX)/AREP
            C     CONVERT - MILES*(LB/GAL)/(LB)
ISN 0173          GAMD = 7.5     *6.17/(FUEL)
ISN 0174          EMD(N,M,15) = (
                 1EMD(N,M,15) + GAMD)/AREP
ISN 0175          DO 21 I=1,2
ISN 0176          PERB(I) = (PERB(I) + PER2(I))/AREP
ISN 0177          PERD(I) = (PERD(I) + PER3(I))/AREP
ISN 0178       21 CONTINUE
ISN 0179           DO 22 I=2,14
ISN 0180           DCB(I) = (DCB(I) + DC2(I))/AREP
ISN 0181           DHB(I) = (DHB(I) + DH2(I))/AREP
ISN 0182           DCD(I) = (DCD(I) + DC3(I))/AREP
ISN 0183           DHD(I) = (DHD(I) + DH3(I))/AREP
ISN 0184        22 CONTINUE
ISN 0185           EBHC = EMD(N,M,2)
ISN 0186           EBCO = EMD(N,M,3)
ISN 0187           EBNO = EMD(N,M,5)
ISN 0188           EDHC = EMD(N,M,7)
ISN 0189           EDCO = EMD(N,M,8)
ISN 0190           EDNO = EMD(N,M,10)
ISN 0191        25 CONTINUE
              C    SAFETY INDEX
ISN 0192           SIG = DD(M,3)
              C    EMISSION INDEX
ISN 0193           DELHC  = EBHC - EDHC
ISN 0194           DELCO  = EBCO - EDCO
ISN 0195           DELNO  = EBNO - EDNO
ISN 0196           DEL = 1.
ISN 0197           IF ((DELHC+EBHC*ERROR).LT.0. .OR. (DELCO+EBCO*ERROR).LT.0. .OR.
                 1    (DELNO+EBNO*ERROR).LT.0.)  DEL = 0.
ISN 0199           DEX (M,17) = DEX(M,17) + (DELHC             )/EBHC
ISN 0200           DEX (M,18) = DEX(M,18) + (DELCO             )/EBCO
ISN 0201           DEX (M,19) = DEX(M,19) + (DELNO             )/EBNO
ISN 0202           OMHC   = ESHC - EDHC
ISN 0203           OMCO   = ESCO - EDCO
ISN 0204           OMNO   = ESNO - EDNO
ISN 0205           OMEGA  = 1.
ISN 0206           IF(OMHC .LT.0. .OR. OMCO .LT.0. .OR. OMNO .LT.0.) OMEGA = 0.
ISN 0208           DEX (M, 6) = DEX(M, 6) + OMHC
ISN 0209           DEX (M, 7) = DEX(M, 7) + OMCO
ISN 0210           DEX (M, 8) = DEX(M, 8) + OMNO
ISN 0211           EIPRM  =     (BH *DELHC/EBHC + BC *DELCO/EBCO + BN *DELNO/EBNO)
ISN 0212           ESMC = DD(M,1)
ISN 0213           EI = EIPRM/(BH+BC+BN)
ISN 0214           DEX (M,20) = DEX(M,20) + EI
ISN 0215           EMD(N,M,11) = EI
              C    DRIVABILITY INDEX
ISN 0216       109 CONTINUE
ISN 0217            DO 110 I=4,15
ISN 0218            DC(N,I) = DCD(I) - DCB(I)
ISN 0219            DH(N,I) = DHD(I) - DHB(I)
ISN 0220        110 CONTINUE
ISN 0221            CSTRT = CCD(  2)*DCD(  3) - DCB(  2)*DCB(  3)
ISN 0222            HSTRT = DHD(  2)*DHD(  3) - DHB(  2)*DHB(  3)
ISN 0223            PER(N,1) = PERD(1) - PERB(1)
ISN 0224            DDEL = DC(N, 6)+DC(N, 7)+DH(N, 5)+DH(N, 6)+DH(N, 7)
ISN 0225            IF (DDEL .GT. 0.) DEX(M,4) = 0.
ISN 0227            DIC =
                   1 (DA( 1)*DC(N, 4)+DA( 2)*DC(N, 5)+DA( 3)*DC(N, 8)+DA( 4)*DC(N, 9)+
                   2  DA( 5)*DC(N,10)+DA( 6)*DC(N,11)+DA( 7)*DC(N,12))+DA(14)*CSTRT
ISN 0228            DIH =
                   3 (DA( 8)*DH(N, 4)+DA(13)*DH(N,12)+DA(11)*DH(N,10)+DA(12)*DH(N,11)+
                   4  DA( 9)*DH(N, 8)+DA(10)*DH(N, 9))+DA(15)*HSTRT
ISN 0229            DIPER =
                   5  DA(16)*PER(N,1)
ISN 0230            DEX (M,22) = DEX (M,22) + DIC
ISN 0231            DEX (M,23) = DEX (M,23) + DIH
ISN 0232            DEX (M,24) = DEX(M,24) + PER(N,1)
ISN 0233            DI = (DIC+DIH+DIPER)/(3.*ASUM)
ISN 0234            IF (DI .GT. ETA) DEX (M, 9) = 0.
ISN 0236            DEX (M,21) = DEX(M,21) + DI
ISN 0237            EMD(N,M,12) = DI
              C     CLEAR TEMPORARY DRIVABILITY DATA STORAGE AREA
ISN 0238            DO 200 I=1,2
ISN 0239            PERB (I) = 0.
ISN 0240            PERD (I) = 0.
ISN 0241        200 CONTINUE
ISN 0242            DO 210 I=2,14
ISN 0243            DCB (I) = 0.
ISN 0244            DHB (I) = 0.
ISN 0245            DCD (I) = 0.
ISN 0246            DHD (I) = 0.
ISN 0247        210 CONTINUE
              C     RECURRING COST INDEX
ISN 0248            MMBF = DD(M,4)
ISN 0249            MTTR = DD(M,5)
ISN 0250            MMTM = DD(M,6)
ISN 0251            MTTM = DD(M,7)
ISN 0252          MMBPF = CD(M, 8)
ISN 0253          CRP = DD(M,10)
ISN 0254          CMP = DD(M,11)
ISN 0255          IF (MMBF .EQ. MMBPF) CRP  = 0.
ISN 0257          IF (MMBF .EQ. MMBPF) MTTR = 0.
ISN 0259          CRRI  = (MTTR/MMBPF+ MTTM/MMTM)*CLAB +   CMP   /MMTM+  CRP  /MMBPF
ISN 0260          DEX (M,12) = DEX(M,12) + (GAMB - GAMD)
ISN 0261          CREI  = (1./GAMD - 1./GAMB)*GAS
ISN 0262          RCPRM =(CRRI + CREI)
ISN 0263          RCGAM = 1.0
ISN 0264          IF(RCPRM.GT. CLR ) RCGAM = 0.0
ISN 0266          CI =(DD(M, 2) + RCPRM)*100.
ISN 0267          DEX (M,11) = DEX(M,11) + RCPRM
ISN 0268          CEI = EI / CI
ISN 0269          DEX (M,25) = DEX(M,25) + CI
ISN 0270          DEX (M,27) = DEX(M,27) + CEI
ISN 0271          EMD(N,M,13) = CI
ISN 0272          EMD(N,M,17) = CEI
ISN 0273          EPS = DEX (M,10)
ISN 0274            R = DEX (M,13)
ISN 0275            A = DEX (M,14)
ISN 0276           EM = DEX (M,15)
ISN 0277          DDEL= DEX (M, 4)
ISN 0278           PI = DEX (M, 9)
ISN 0279          GONOGO = DEL*OMEGA*DDEL*SIG*EPS*RCGAM*R*A*EM*PI
ISN 0280          IF (GONOGO .EQ. 0.) DEX (M, 2) = 0.
ISN 0282          PRATE = (WT1*EI - WT2*DI - WT3*CI) / (WT1+WT2+WT3)
ISN 0283          EMD(N,M,16) = PRATE
ISN 0284          PERFI(N,M) = PRATE
ISN 0285          DEX (M, 1) = DEX(M, 1) + PRATE
ISN 0286          DKT(M) = DKT(M) + 1.
              C
              C       OUTPUT ROUTINE
              C
ISN 0287        800 CONTINUE
ISN 0288            IF (NCAR .EQ. N) GO TO 803
ISN 0290            IF (LINE+33 .LE. 48) GO TO 802
ISN 0292        801 WRITE(6,3000)
ISN 0293       3000  FORMAT ('1',T5 ,'ANA&DET RETROFIT DEVICE TEST RESULTS'//
                    +T10,'*** NOTE ***  ALL ITEMS INPUT ON CARDS MUST BE FILLED WITH DA
                    +TA. IF INCOMPLETE OR INVALID, THE OUTPUT RESULTS '/T10,'AFFECTED B
                    +Y THAT INPUT WILL ALSO BE INVALID BUT WILL BE PRINTED.'//)
ISN 0294            LINE = 6
ISN 0295         802 NCAR = N
ISN 0296             WRITE(6,3010) N
ISN 0297        3010 FORMAT (T5, 'CAR NUMBER  ',I2//T10,'DEVICE   TEST       HC       C
                    +O        NOX   FUEL,MPG      EMISSION   DRIVEABILITY   COST    PERFO
                    +RMANCE    C-E'/T68,'INDEX         INDEX        INDEX        INDEX
                    + INDEX')
ISN 0298             WRITE(6,3020) ARHC(N),ARCO(N),ARNO(N),ARGAS(N)
ISN 0299        3020 FORMAT (T17,'AS REC''D',4(2X,F7.3)/)
ISN 0300             LINE = LINE + 6
ISN 0301         803 CONTINUE
ISN 0302             WRITE(6,3030) DD(M,20),
                    +                  EMD(N,M, 2),EMD(N,M, 3),EMD(N,M, 5),EMD(N,M,14)
ISN 0303        3030 FORMAT (T11,F4.0, '  BASELINE',4(2X,F7.3))
ISN 0304             WRITE(6,3040)   EMD(N,M, 7),EMD(N,M, 8),EMD(N,M,10),EMD(N,M,15),
                    +     EMD(N,M,11),EMD(N,M,12),EMD(N,M,13),EMD(N,M,16),EMD(N,M,17)
ISN 0305        3040 FORMAT (T17,'RETROFIT',4(2X,F7.3),1X,3(6X,F6.3),2(4X,F7.3)/)
ISN 0306             LINE = LINE + 3
ISN 0307             DO 810 II=1,17
ISN 0308         810 EMD(N,M,II) = 0.
ISN 0309             GO TO 9
ISN 0310         900 CONTINUE
ISN 0311             WRITE(6,2010) NRUNA
ISN 0312        2010 FORMAT('1      ***** TESTID CODING ERROR FOR RUN NUMBER',I8,' ***')
ISN 0313             IF (MT .NE. 2) GO TO 16
ISN 0315             GO TO 999
ISN 0316         915 CONTINUE
ISN 0317             WRITE(6,2020)
ISN 0318        2020 FORMAT('1      ***** EMISSION DATA INPUT COMPLETE *****')
ISN 0319         950 CONTINUE
ISN 0320         955 CONTINUE
ISN 0321             DO 957 I=1,12
ISN 0322             IF (DKT(I) .EQ. 0.) GO TO 957
ISN 0324             DEX(I, 1) = DEX(I, 1)/DKT(I)
ISN 0325             DEX(I, 6) = DEX(I, 6)/DKT(I)
ISN 0326             DEX(I, 7) = DEX(I, 7)/DKT(I)
ISN 0327             DEX(I, 8) = DEX(I, 8)/DKT(I)
ISN 0328               DEX(I, 5) = 1.
ISN 0329             IF (DEX(I, 6).LT.O. .OR. DEX(I, 7).LT.O. .OR. DEX(I, 8).LT.O.)
                   1  DEX(I, 5) = 0.
ISN 0331             DEX(I,11) = DEX(I,11)/DKT(I)
ISN 0332            REC (I) = DEX(I,11)
ISN 0333            IF ( REC (I)  .LE.  CLR ) DEX(I,11) = 1.
ISN 0335            IF ( REC (I)  .GT.  CLR ) DEX(I,11) = 0.
ISN 0337            REC(I) = REC(I)*100.
ISN 0338            DEX(I,12) = DEX(I,12)/DKT(I)
ISN 0339            DEX(I,17) = DEX(I,17)/DKT(I)
ISN 0340            DEX(I,18) = DEX(I,18)/DKT(I)
ISN 0341            DEX(I,19) = DEX(I,19)/DKT(I)
ISN 0342              DEX(I,16) = 1.
ISN 0343            IF ((DEX(I,17)+ERROR).LT.0. .OR. (DEX(I,18)+ERROR).LT.0. .OR.
                   1     (DEX(I,19)+ERROR).LT.0.)  DEX(I,16) = 0.
ISN 0345            DEX(I,20) = DEX(I,20)/DKT(I)
ISN 0346            DEX(I,21) = DEX(I,21)/DKT(I)
ISN 0347            DEX(I,22) = DEX(I,22)/DKT(I)
ISN 0348            DEX(I,23) = DEX(I,23)/DKT(I)
ISN 0349            DEX(I,24) = DEX(I,24)/DKT(I)
ISN 0350            DEX(I,25) = DEX(I,25)/DKT(I)
ISN 0351            DEX(I,27) = DEX(I,20)/DEX(I,25)
ISN 0352        956 CONTINUE
ISN 0353        957 CONTINUE
ISN 0354            WRITE (6,3050)
ISN 0355       3050  FORMAT ('1ANA&DET RETROFIT PERFORMANCE ANALYSIS RESULTS'//
                   +T10,'*** NOTE ***  ALL ITEMS INPUT ON CARDS MUST BE FILLED WITH DA
                   +TA. IF INCOMPLETE OR INVALID, THE OUTPUT RESULTS '/T10,'AFFECTED B
                   +Y THAT INPUT WILL ALSO BE INVALID BUT WILL BE PRINTED.'//)
ISN 0356            WRITE (6,3055) (CD(I,20),I=1,11)
ISN 0357       3055  FORMAT ( T7,'DEVICE NUMBER',T35,11(F4.0,4X) )
ISN 0358            WRITE(6,3056) (DKT(I),I=1,11)
ISN 0359       3056  FORMAT (T9,'NUMBER OF TESTS',T35,11(F4.0,4X)/)
ISN 0360            WRITE (6,3060) ((DEX(I,J),I=1,11),J=2,10),(DEX(I,26),I=1,11)
ISN 0361       3060  FORMAT (
                   +         T3,'CRITERIA INDEX',T37,11(F3.1,5X)//
                   +         T7,'SAFETY FACTOR', T37,11(F3.1,5X)/
                   +         T7,'CRITICAL DRIVABILITY FACTOR',T37,11(F3.1,5X)/
                   +         T7,'EMISSION STANDARDS FACTOR',  T37,11(F3.1,5X)/
                   +         T9,'HC  REDUC FROM STD ,GM/M',T34,11(F7.2,1X)/
                   +         T9,'CO  REDUC FROM STD ,GM/M',T34,11(F7.2,1X)/
                   +         T9,'NOX REDUC FROM STD ,GM/M',T34,11(F7.2,1X)/
                   +         T7,'GENERAL DRIVABILITY FACTOR',T37,11(F3.1,5X)/
                   +         T7,'INSTALLATION COST FACTOR',  T37,11(F3.1,5X)/
                   +         T9,'DEVICE COST, INSTALLED',T35,11(F6.2,2X) )
ISN 0362            WRITE (6,3061)(DEX(I,11),I=1,11),(REC(I),I=1,11),
                   +               ((DEX(I,J),I=1,11),J=12,19)
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ISN 0363      3061  FORMAT (T7,'RECURRING COST FACTOR',      T37,11(F3.1,5X)/
                +         T9,'REC. COST,$/100 MI',T35,11(F7.3,1X)/
                +         T9,'FUEL MILEAGE LOSS,MPG',T36,11(F5.2,3X)/
                +         T7,'RELIABILITY FACTOR',       T37,11(F3.1,5X)/
                +         T7,'MAINTAINABILITY FACTOR',   T37,11(F3.1,5X)/
                +         T7,'AVAILABILITY FACTOR',      T37,11(F3.1,5X)/
                +         T7,'EMISSION BASELINE FACTOR',T37,11(F3.1,5X)/
                +         T9,'HC  REDUC FROM BASE,%    ',T35,11(F7.3,1X)/
                +         T9,'CO  REDUC FROM BASE,%    ',T35,11(F7.3,1X)/
                +         T9,'NOX REDUC FROM BASE,%    ',T35,11(F7.3,1X)//)
ISN 0364            WRITE (6,3064) (DEX(I,1),I=1,11)
ISN 0365      3064  FORMAT (T3,'PERFORMANCE INDEX',T35,11(F7.3,1X)/)
ISN 0366            WRITE (6,3065) ((DEX(I,J),I=1,11),J=20,25),(DEX(I,27),I=1,11)
ISN 0367      3065  FORMAT (T5,'EMISSION INDEX              ',   T36,11(F6.3,2X)//
                +         T5,'DRIVABILITY INDEX            ',T35,11(F7.3,1X)/
                +         T7,'COLD START PENALTY,WTED SUM',T35,11(F5.1,3X)/
                +         T7,'HOT  START PENALTY,WTED SUM',T35,11(F5.1,3X)/
                +         T7,'ACCELERATION LOSS,SECONDS',T35,11(F5.1,3X)//
                +         T5,'COST INDEX         ',T36,11(F7.4,1X)///
                +         T3,'COST-EFFECTIVENESS INDEX',T33,11(F8.2    ))
ISN 0368            WRITE (6,3066) (DD(I,17),I=1,11)
ISN 0369      3066  FORMAT (/T3,'ADAPTABILITY, % OF POPULATION',T35,11(F6.2,2X))
ISN 0370            ISORT = 1
ISN 0371       958  WRITE (6,3050)
ISN 0372            LCT = 5
ISN 0373       959  CONTINUE
ISN 0374       960  WRITE (6,3070)
ISN 0375      3070  FORMAT (T5,'***  SORTED BY DEVICE NUMBER  ***'/)
ISN 0376       970  CONTINUE
ISN 0377            LCT = LCT + 2
ISN 0378            IF (LCT .GT. 10) GO TO 972
ISN 0380            WRITE (6,3077)
ISN 0381      3077  FORMAT (T7,'DEVICE     CRITERIA  *  EMISSION     DRIVABILITY     C
                +OST      PERFORMANCE    *       C/E          COST'/
                +         T7,'NUMBER       INDEX   *   INDEX          INDEX       IN
                +DEX         INDEX       *       INDEX      INSTALLED,$'/)
ISN 0382            LCT = LCT + 4
ISN 0383       972  CONTINUE
ISN 0384            DO 973 I=1,12
ISN 0385            DECK(I, 1) = DD (1,20)
ISN 0386             IF (DECK(I,1) .EC. 0.) GO TO 973
ISN 0388             DECK(I, 2) = DEX(I, 2)
ISN 0389             DECK(I, 3) = DEX(I,20)
ISN 0390             DECK(I, 4) = DEX(I,21)
ISN 0391             DECK(I, 5) = DEX(I,25)
ISN 0392             DECK(I, 6) = DEX(I, 1)
ISN 0393             CECK(I, 7) = DEX(I,27)
ISN 0394             DECK(I, 8) = DEX(I,26)
ISN 0395             WRITE (6,3080) (DECK(I,J),J=1,8)
ISN 0396      3080   FORMAT (T8,F4.0,T19,F3.1,T31,F6.3,T45,F7.3,T59,F5.3,T72,F6.3,T84,
                    +        '*',T90,F6.2,T104,F6.2,T28,'*')
ISN 0397       973  CONTINUE
ISN 0398             WRITE (6,3081) WT1,WT2,WT3
ISN 0399      3081   FORMAT (T7,'*     *     *     *     *     *     *     *
                    +  *     *     *     *     *     *     *     *     *'//T6,'WEIGHTING
                    +'/T7,'FACTORS',T31,F5.2,T47,F5.2,T57,F6.2//
                    + T10,'***  NOTE  ***  NEGATIVE C/E VALUES ARE MEANINGLESS WHEN EMI
                    +SSION INDEX IS NEGATIVE')
ISN 0400       999  CONTINUE
ISN 0401             WRITE(6,3082)
ISN 0402      3082   FORMAT('1')
ISN 0403             STOP
ISN 0404             END
```

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LEVEL 18 ( SEPT 69 )                                      OS/360  FORTRAN H        DATE  72.083/10.40.39

            COMPILER OPTIONS - NAME=  MAIN,OPT=00,LINECNT=42,SIZE=C000K,
                               SOURCE,EBCDIC,NOLIST,NODECK,LOAD,MAP,NOEDIT,ID,NOXREF
                   C
  ISN 0002                SUBROUTINE MASS(PBAR,PIN,POUT,TMIX,REV,CHC,CCO,CCO2,CNOX,VR,
                        1                 MHC,MCO,MCO2,MNOX)
                   C
                   C      THIS ROUTINE CALCULATES THE GRAMS PER MILE EMITTED
                   C      FOR THE POLLUTANTS HC, CO, CO2, AND NOX
                   C
                   C      THE VARIABLES USED IN THE ARGUMENT LIST ARE
                   C      DEFINED IN THE MAIN PROGRAM
                   C
                   C
  ISN 0003                REAL MHC,MCO,MCO2,MNOX,MNOXO
  ISN 0004                DIMENSION STAB(6,5)
  ISN 0005                COMMON STAB,AK0,AK1,TWET,TDRY,H,HUCF
                   C      CONVERT INCHES OF MERCURY TO INCHES CF WATER
  ISN 0006                PIN = PIN*(408./29.92)
  ISN 0007                VO = AK0 + AK1*(PIN)
  ISN 0008                IF (VR .NE. 0.) VO = VR
                   C      CONVERT INCHES OF WATER TO INCHES OF MERCURY
  ISN 0010                PIN = PIN*(29.92/408.)
  ISN 0011                VMIX =(0.09263*VO*REV*(PBAR-PIN)/(TMIX+460.))*25.4
  ISN 0012                MHC  =(VMIX*16.33      /1000000.)*CHC
  ISN 0013                MCO  =(VMIX*32.97      /100.)*CCO
  ISN 0014                MCO2 =(VMIX*48.54      /100.  )*CCO2
  ISN 0015                CALL HUM(PBAR)
  ISN 0016                MNOXO=(VMIX*54.16      /1000000. )*CNCX
  ISN 0017                MNOX = MNOXO*HUCF
                   C      WRITE(6,1000) VO,VMIX,MHC,MCO,MCO2,MNOX,HUCF,CHC,CCO,CCO2,CNOX
                   C1000 FORMAT (T 5,'MASS CALCULATION RESULTS'/T10,,11F10.5)
  ISN 0018                RETURN
  ISN 0019                END
```

```
LEVEL 18 ( SEPT 69 )                              OS/360  FORTRAN H         DATE  72.083/10.40.42

           COMPILER OPTIONS - NAME=  MAIN,OPT=00,LINECNT=42,SIZE=0000K,
                              SOURCE,EBCDIC,NOLIST,NODECK,LOAD,MAP,NOEDIT,ID,NOXREF
                 C
  ISN 0002              SUBROUTINE HUM(PBAR)
                 C
                 C      THIS ROUTINE FURNISHES THE ABSOLUTE HUMIDITY IN GRAINS OF
                 C      WATER POUND OF DRY AIR AND RETURNS THE HUMIDITY
                 C      CORRECTION FACTOR USED IN THE NOX CALCULATION
                 C
                 C
                 C      INPUTS -
                 C            TWET - THE WET BULB TEMPERATURE IN DEGREES FAHRENHEIT
                 C            TDRY - THE DRY BULB TEMPERATURE IN DEGREES FAHRENHEIT
                 C            PBAR - THE BAROMETRIC PRESSURE IN INCHES OF MERCURY
                 C            STAB - STEAM TABLE VALUES ABRIDGED FROM KEENAN & KEYES
                 C
                 C      OUTPUTS -
                 C            H    - THE ABSOLUTE HUMIDITY
                 C            HUCF - THE HUMIDITY CORRECTION FACTOR
                 C
  ISN 0003              DIMENSION STAB(6,5)
  ISN 0004              COMMON STAB,AK0,AK1,TWET,TDRY,H,HUCF
  ISN 0005              KW = 1. + (TWET - 50.)/10.
  ISN 0006              KD = 1. + (TDRY - 50.)/10.
  ISN 0007              AK = KW*10 + 40
  ISN 0008              VGW  = STAB(KW,1) - (STAB(KW,1) - STAB(KW+1,1))*(TWET - AK)/10.
  ISN 0009              HFW  = STAB(KW,2) - (STAB(KW,2) - STAB(KW+1,2))*(TWET - AK)/10.
  ISN 0010              HFGW = STAB(KW,3) - (STAB(KW,3) - STAB(KW+1,3))*(TWET - AK)/10.
  ISN 0011              PW   = STAB(KW,5) - (STAB(KW,5) - STAB(KW+1,5))*(TWET - AK)/10.
  ISN 0012              AD = KD*10 + 40
  ISN 0013              HGD  = STAB(KD,4) - (STAB(KD,4) - STAB(KD+1,4))*(TDRY - AD)/10.
  ISN 0014              HN =(53.342*(460.+TWET)/(144.*VGW*(0.491*PBAR-PW)))* HFGW -
                      1      0.24*(TDRY - TWET)
  ISN 0015              H  = HN*7000./(HGD - HFW)
  ISN 0016              HUCF = 1./(1. - 0.0047*(H - 75.))
                 C      WRITE(6,1000) TWET,TDRY,PBAR,KW,KD,AK,AD,VGW,HFW,HFGW,PW,HGD,
                 C    1                HN,H,HUCF
                 C1000 FORMAT (T 5,'HUMIDITY CALCULATION RESULTS'/T10,3F5.2,2I5,
                 C    1          2F8.1,2(3F8.2,F8.4))


  ISN 0017              RETURN
  ISN 0018              END
```